CHAPTER 6

TUBING FABRICATION AND MAINTENANCE

Chapter Objective: *Upon completion of this chapter, you will have a working knowledge of aircraft hydraulic and pneumatic tubing and their associated hardware.*

Tubing assemblies are used to transport liquids or gas (usually under pressure) between various components of the aircraft system. Tube assemblies are used in aircraft for fuel, oil, oxidizer, coolant, breathing oxygen, instruments, hydraulic, and vent lines. You must be familiar with the procedures for testing and fabricating tubing assemblies, and you must recognize the various tools and equipment and how to identify the different uses of tubing in naval aircraft. Tube assemblies are fabricated from rigid tubing and associated fittings.

TUBING AND TUBE ASSEMBLIES

Learning Objective: *Recognize the various materials, tools, equipment, and testing procedures used in the fabrication of hydraulic and pneumatic tubing assemblies.*

TYPES OF TUBING

The tubing used in the manufacture of rigid tubing assemblies is sized by outside diameter (OD) and wall thickness. Outside diameter sizes are in sixteenth-inch increments; the number of the tube indicates its size in sixteenths of an inch. Thus, No. 6 tubing is 6/16 or 3/8 inch; No. 8 tubing is 8/16 or 1/2 inch, etc. Wall thickness is specified in thousandths of an inch. The most common types of tubing are the corrosion-resistant steel tubing for high pressure and the aluminum alloy tubing for high pressure and general-purpose.

Corrosion-Resistant Steel Tubbing

Corrosion-resistant steel tubing (CRES) is used in high-pressure hydraulic systems (3,000 psi and above) such as landing gear, wing flaps, and brakes. The tubing does not have to be annealed for flaring or forming. The flared section is strengthened by cold working and consequent strain hardening. Table 6-1 lists the most commonly used corrosion-resistant steel tubing in naval aircraft and includes some of the designations by which the corrosion steel tubing is known. Application notes are intended as guidelines.

Corrosion-resistant steel tube assemblies fabricated with corrosion-resistant steel tubing MIL-T-6845 are authorized for repair or replacement for any line provided no attempt is made to weld or braze the tubing. MIL-T-6845 tubing is not to be substituted for British DTD-5016 annealed stainless steel tubing.

Aluminum Alloy Tubing

Aluminum alloy tubing is used for both high-pressure and general-purpose lines. Table 6-2 lists the most commonly used aluminum alloy tubing and its applications. Use of aluminum alloy tubing is limited in certain areas of airborne hydraulic systems by MIL-H-5440. Refer to the applicable drawing and the illustrated parts breakdown to determine the correct tubing for a particular system. Aluminum alloy tube assemblies fabricated with aluminum alloy tubing 6061-T6 are authorized for repair or replacement for any aluminum line. MIL-T-6845 Cres tubing (304-1/8H) is a suitable substitute for all aluminum alloy tubing when 6061-T6 is unavailable.

Special Tubing

Corrosion-resistant steel 21-6-9 and titanium alloy 3AL-2.5V are presently being incorporated into new model aircraft. Repair and fabrication of assemblies using these materials may require special procedures. Refer to the applicable maintenance directives for specific details.

TUBE FITTINGS

Fittings for tube connections are made of aluminum alloy, titanium steel, corrosion-resistant steel, brass, and bronze. Fittings are made in many configurations and styles. The usual classifications are flared-tube fittings, flareless-tube fittings, brazed, welded, and swaged fittings (figs. 6-1 through 6-4). Refer to table 6-3, for identification of fittings.

Table 6-1.—Corrosion-Resistant Steel Tubing

Specification Tubing Material	Type	Condition	General Usage and Applications
MIL-T-7081	6061 A1		Specification covers annealed and three heat treated tempers used mostly in 0-annealed and T-6. Has good workability. The 6061-T6 is used in hydraulic/pneumatic 3000 psi systems.
MIL-T-8506 18-8 Corrosion-Resistant Steel (CRES)	304	Annealed	Low-pressure applications such as fuel lines. Unsatisfactory for high-pressure hydraulic lines. Has high degree of resistance to corrosion.
MIL-T-8504 18-8 CRES	304	Annealed	Unsatisfactory for welding, brazing or exposure to temperatures higher than 800°F. Used in high-pressure hydraulic/pneumatic systems.
MIL-T-8606 18-8 CRES	304L (low carbon) 321 347	Annealed	Hydraulic/mechanical applications. Has high resistance to corrosion and high temperatures up to 1500°F. Suitable for applications requiring welding/brazing. Type II intended for high-pressure hydraulic applications, using brazed sleeve joints.
MIL-T-6845 18-8 CRES	304	1/8H	Used in high-pressure hydraulic/pneumatic systems. Unsuitable for welding/brazing applications or exposure to temperatures above 800°F.
MIL-T-8973 18-8 CRES	304L (low carbon) 316L (low carbon) 321 347	1/8H	Used in high-pressure hydraulic/pneumatic systems assembled with brazed sleeve joints. Suitable for use in moderately corrosive or oxidizing environments, temperatures to 1200°F. Weldable.
MIL-T-5695 18-8 CRES	304	1/4H 1/2H	Used for aircraft structural parts or similar applications not requiring sharp bends or flaring. Unsatisfactory for welding other than resistance weld.
MIL-T-8808 18-8 CRES	321 347	Annealed	Aircraft hydraulic quality, used in high-pressure hydraulic/pneumatic systems. Most often used in these systems requiring brazing/welding.

Table 6-2.—Aluminum Alloy Tubing Applications

Old Specification	New Specification	Type	General Usage and Applications
WW-T-383	WW-T-700/1	1100 - 0 -H12 -H14 -H16 -H18	**CAUTION** Tubing conforming to Federal Specification WW-T-700/1 shall not be used in hydraulic systems. Specification covers tempers from annealed to full-hard. Used mostly in O-annealed condition. Good formability. Used where high strength is not necessary, as in low- or negative-pressure (nonhydraulic) lines.
WW-T-787	WW-T-700/4	5052 - 0 -H32 -H34 -H36 -H38	Specification covers tempers from annealed to full-hard. Used mostly in O-annealed condition. Has good workability. Used in medium-pressure systems (1500 psi max.)
WW-T-789	WW-T-700/6	6061 - 0 - T4 - T61	Specification covers annealed and three heat-treated tempers. Used mostly in O-annealed and T-6. Has good workability. Tubing conforming to Federal Specification WW-T-700/6 shall not be used in hydraulic systems.

[1]Only 6061-T6 is of sufficient strength to use in the repair of aluminum tubing systems. In an emergency, the other alloys of aluminum maybe used with AN fittings to make temporary repairs only.

Table 6-3.—AN/MS Tube Fitting Color Codes

MATERIAL OR FINISH	COLOR
Aluminum Alloy	Blue
Carbon Steel	Black
Corrosion Resistant Steel	Natural
Aluminum-bronze	Cadmium Plate
Titanium	Natural to Grey, Depending on Type and Intended Use.

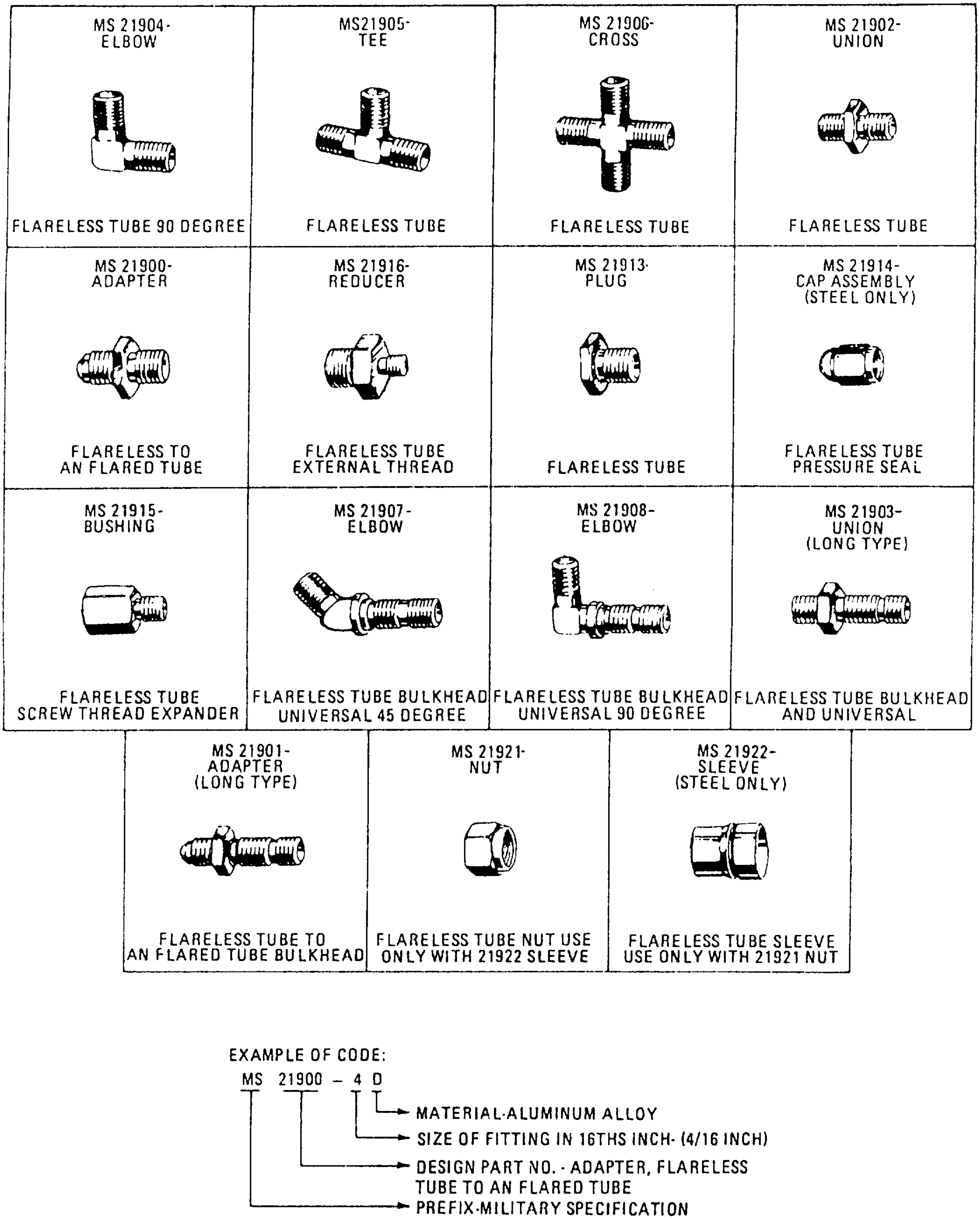


Figure 6-1.—Typical styles of MS fittings.

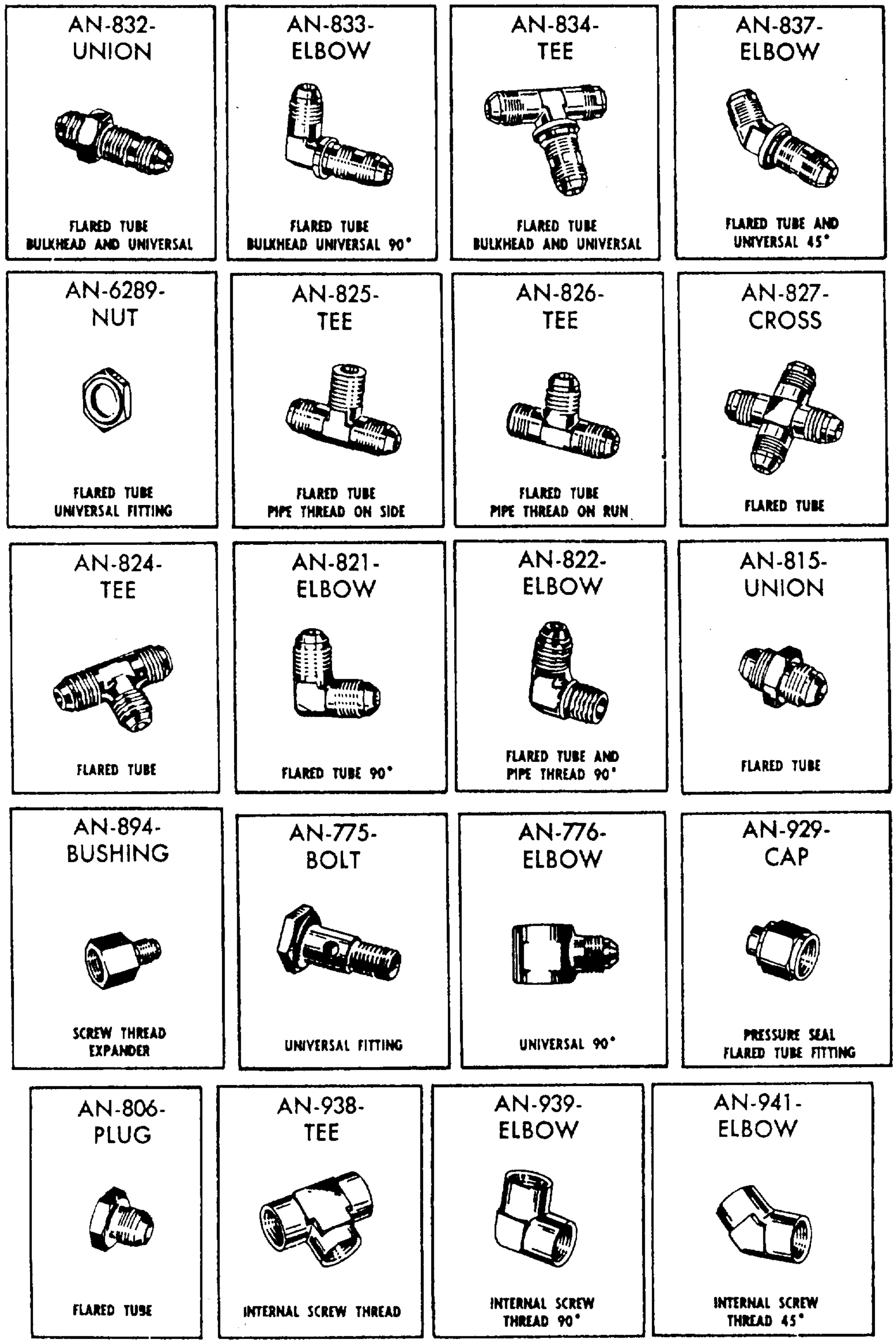
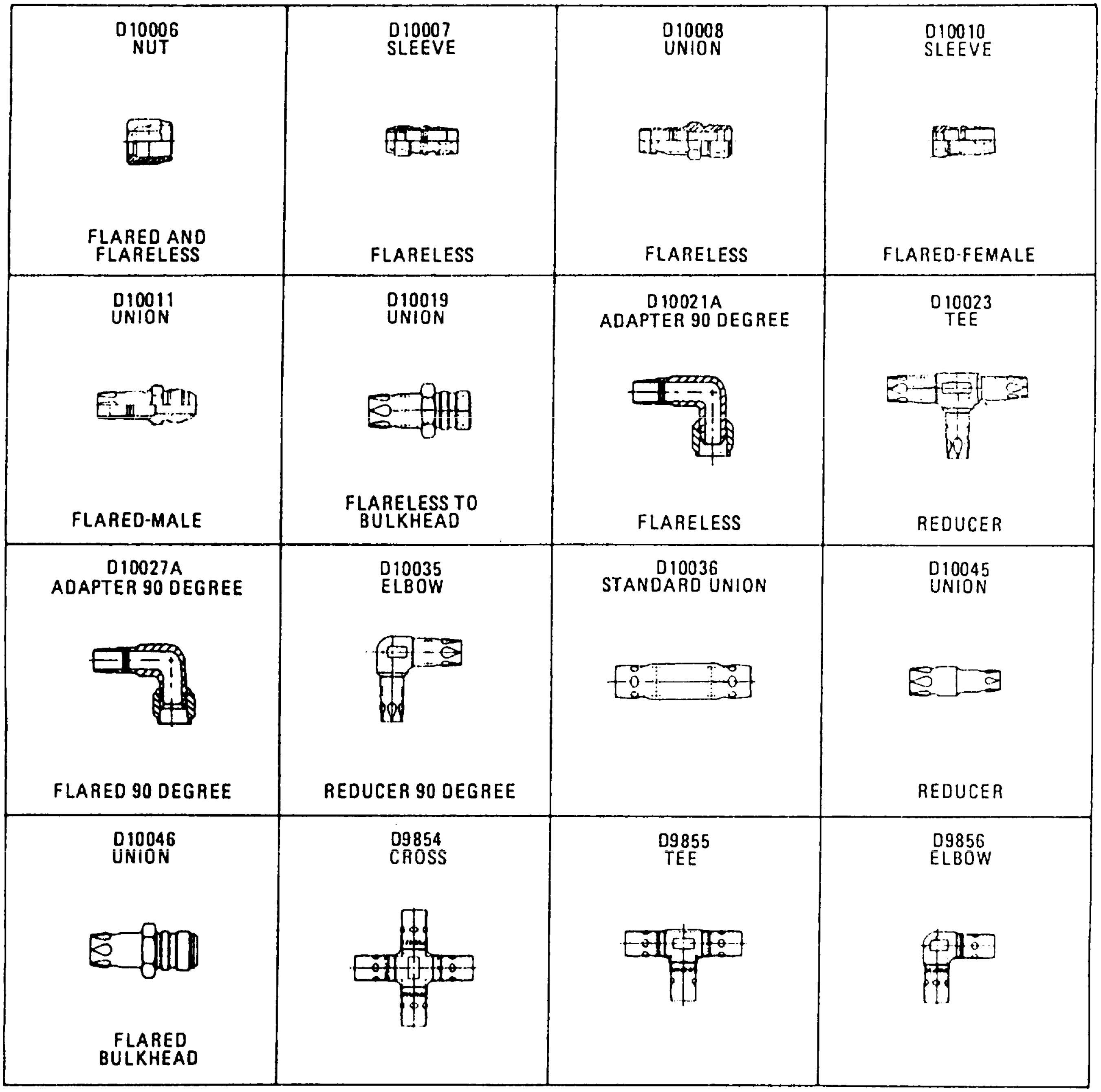


Figure 6-2.—Typical styles of AN fittings.



EXAMPLE OF CODE: D10006 - 6

- TUBE SIZE (3/8 INCH OD)
- MATERIAL (CORROSION RESISTANT STEEL)
- BASIC PART NO.

Figure 6-3.—Typical style of Permaswage fittings.

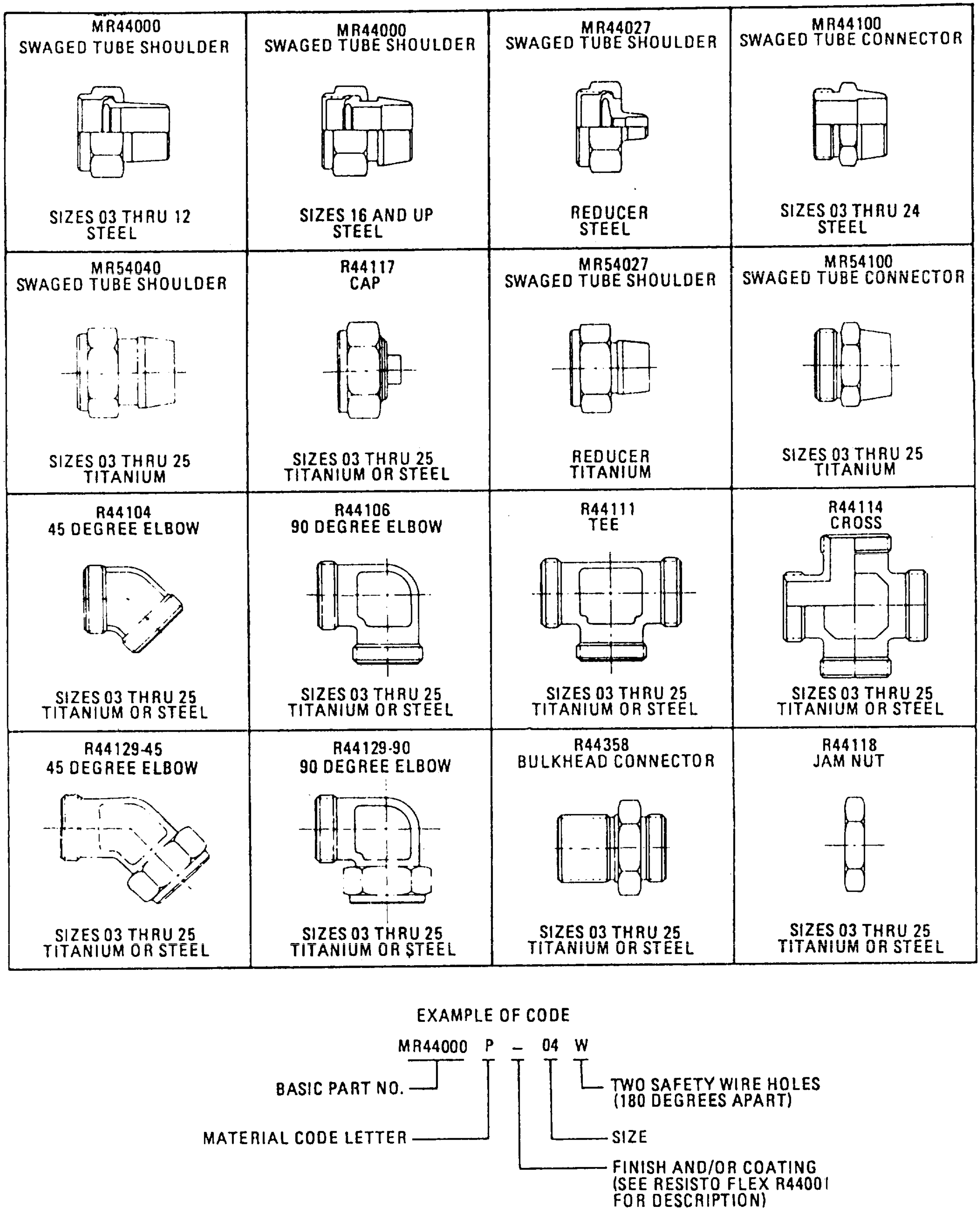


Figure 6-4.—Typical style of Dynatube fittings.

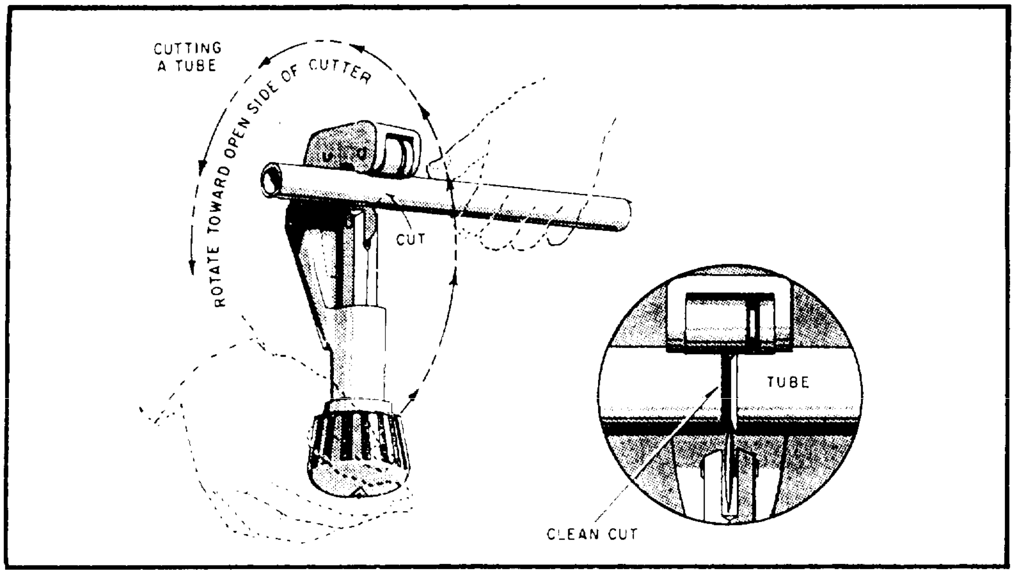


Figure 6-5.—Standard tube cutter.

FABRICATION

Fabrication of tube assemblies consists of tube cuttings, deburring, bending, and tube joint preparation. The procedures found in this chapter are for instructional purposes only. When fabricating tube assemblies, refer to the *Aviation Hose and Tube Manual, NA01-1A-20.*

TUBE CUTTING

When you cut tubing, the objective is to produce a square end free from burrs. Tubing should be cut with a standard tube cutter, or the Permaswage chipless cutter.

Standard Tube Cutter

Place the tube in cutter with cutting wheel at the point where the cut is to be made. Apply light pressure on tube by tightening adjusting knob. Too much pressure applied to the cutting wheel at one time may deform the tubing or cause excessive burrs. Rotate the cutter toward its open side (fig. 6-5). As the cutter is rotated, adjust the tightening knob after each complete turn to maintain light pressure on the cutting wheel.

Permaswage Chipless Cutter

Select the chipless cutter according to tubing size. Rotate cutter head to accept tubing in cutting position. Check to ensure the cutter ratchet is operating freely and the cutter wheel is clear of the cutter head opening (fig. 6-6).

Center the tubing on two rollers and cutting blade. Use the hex key provided with the kit to turn the drive screw in until the cutter wheel touches the tube. Tighten the drive screw one-eighth to one-fourth turn. Do not overtighten the drive screw. Overtightening can damage soft tubing or cause excessive wear or breakage of the cutter wheel in hard tubing. Swing ratchet handle back and forth through the available clearance until there is a noticeable ease of rotation. Avoid side force on cutter handle. Side force will cause the cutter wheel to break. Tighten the drive screw an additional one-eighth to one-fourth turn, and swing ratchet handle back and forth, retightening drive screw as needed until cut is completed.

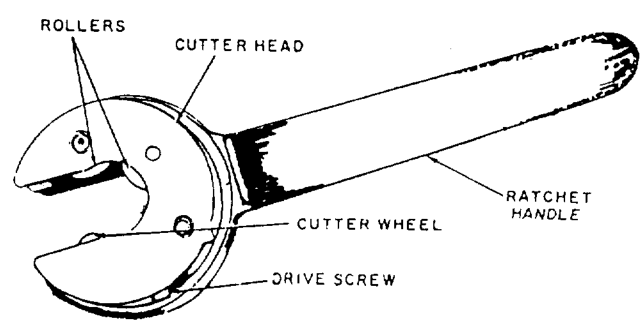


Figure 6-6.—Permaswage chipless cutter.

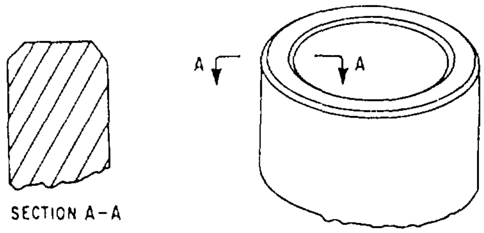


Figure 6-7.—Properly deburred tubing.

If neither tube cutter (standard or Permaswage) is available, a fine-tooth hacksaw should be used to cut tubing. A convenient method for cutting tubing with a hacksaw is to place the tube in a flaring block and the clamp block in a vise. After cutting the tube with a hacksaw, remove all saw marks by filing the tube.

Tube Deburring

After you cut the tubing, remove all burrs and sharp edges from inside and outside of tube (fig. 6-7) with deburring tools. Clean out tubing. Make sure that no foreign particles remain. A Permaswage deburring tool may be used to remove burrs from inside of tubing. Select deburring tool and stem subassembly (fig. 6-8) required for the size of tubing to be deburred. Lubricate the sliding collar on the end of elastic plug with light oil if necessary to get free movement. Engage threads and insert stem subassembly into cutter end of deburring tool by depressing the plunger, and screw stem subassembly into plunger until it bottoms and fingertightens. Check assembly deburring tool. Depress plunger and the plug. Outside diameter should be reduced to the same diameter as metal support collar on either end of elastic plug. Release plunger. Two distinct circumferential bumps will appear on elastic plug beyond outside diameter of metal support collars. Check the tube end for squareness. Check the elastic plug for wear and cleanliness. Replace worn or damaged elastic plug. Clean and lightly lubricate elastic plug with lubricant compatible to hydraulic fluid to be used in tubing. Grasp deburring tool in one hand with two fingers on collar and thumb on plunger. Depress plunger with thumb and insert elastic plug into tube opening until cutter is about 1/8 inch from tube end. If the plug fit is tight due to a large burr on ID of the tube, slowly rotate the plunger end of tool while gently pushing tool into the tube end. Release plunger to allow elastic plug to expand and seal tube opening to prevent chips from entering. Hold tube end and rotate knurled body of deburring tool in a clockwise direction while applying pressure to cutter. Continue rotating tool until resistance decreases, indicating all burrs have been removed from tube ID.

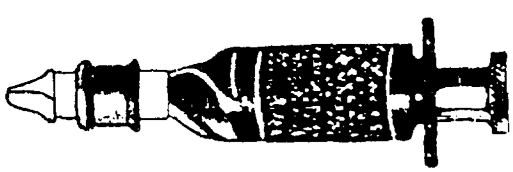


Figure 6-8.—Permaswage deburring foot (typical).

You should avoid excessive deburring, which can cause too deep a chamfer on tube ID. The chamfer should not exceed one-half wall thickness of tubing. Relax pressure and rotate deburring tool several times to produce a smooth surface. Without depressing plunger, ease deburring tool from tube until the first bulge of elastic plug is exposed. Wipe off the tube end and plug. Check the tube end to see if it is completely deburred. If tube end appears saticfactory, without depressing plunger, remove deburring tool from tube. If tube end is not completely deburred, without depressing plunger, push deburring tool back into the tube and repeat all the steps.

TUBE BENDING

The objective in tube bending is to obtain a smooth bend without flattening the tube. Acceptable and unacceptable bends are shown in figure 6-9. Tube bending is usually done by using a mechanical or hand-operated tube bender. In an emergency, soft, nonheat-treated aluminum tubing smaller than 1/4 inch in diameter may be bent by hand to form the desired radius.

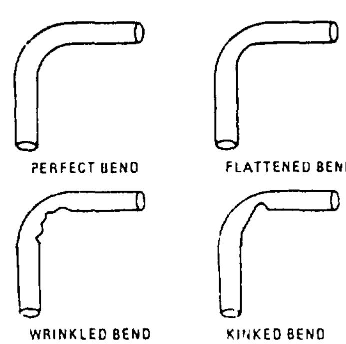


Figure 6-9.—Tubing bends.

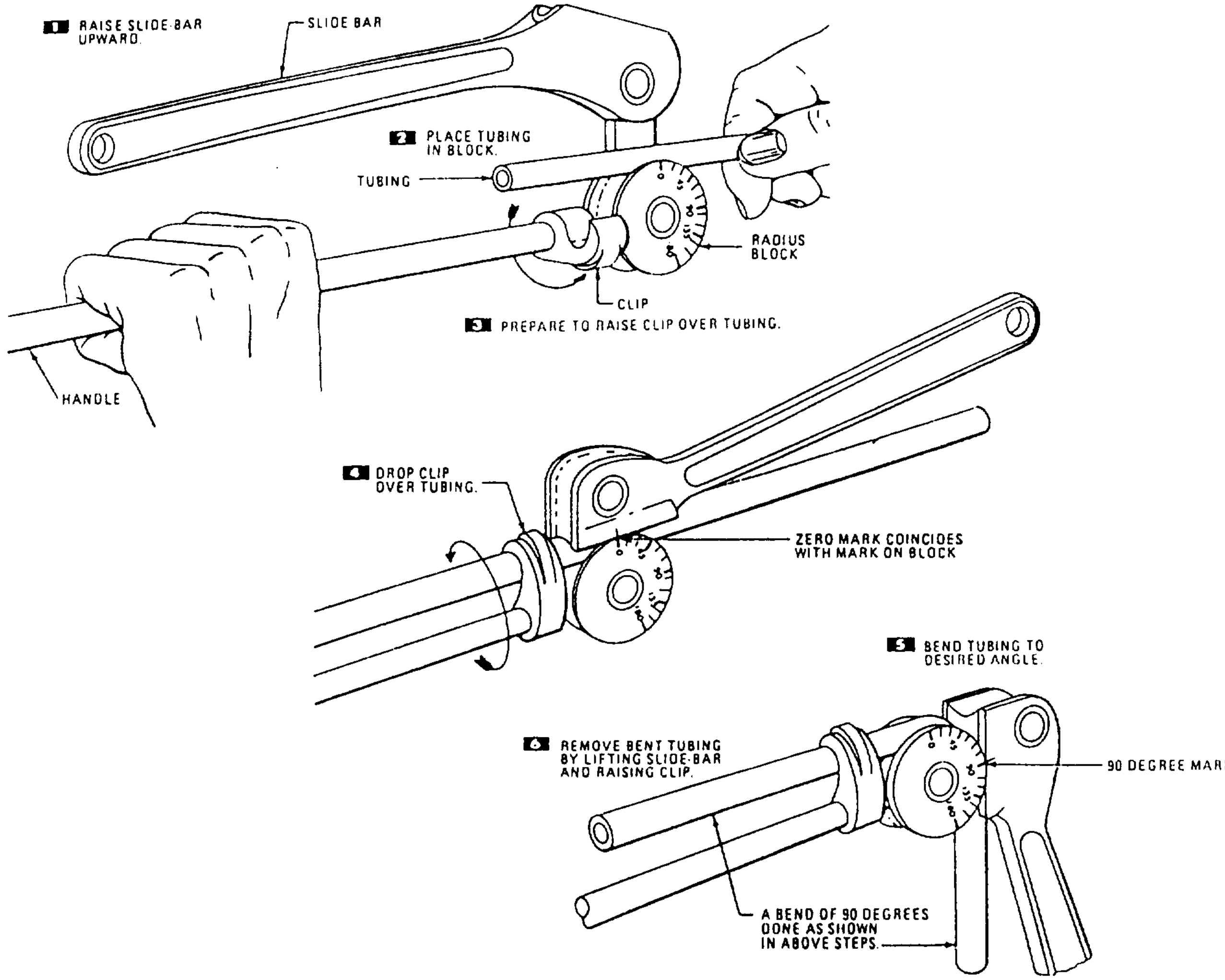


Figure 6-10.—Bending tubing with hand-operated tube bender.

Hand Tube Bender

The hand-operated tube bender, shown in figure 6-10, consists of a handle, radius block, clip, and a slide bar. The handle and slide bar are used as levers to provide the mechanical advantage necessary to bend tubing. The radius block is marked on degrees of bend ranging from 0 to 180 degrees. The slide bar has a mark that is lined up with the zero mark on the radius block. The tube is inserted in the tube bender, and after lining up the marks, the slide bar is moved around until the mark on the slide bar reaches the desired degree of bend on the radius block. See figure 6-10 for the six procedural steps in tube bending with the hand-operated tube bender.

Mechanical Operated Tube Bender

The tube bender, shown in figure 6-11, is issued as a kit. The kit contains the equipment necessary for bending tubing from 1/4 inch to 3/4 inch in diameter. This tube bender is designed for use with aircraft grade, high-strength, stainless-steel tubing, as well as all other metal tubing. It is designed to be fastened to a bench or tripod, and the base is formed to provide a secure grip in a vise.

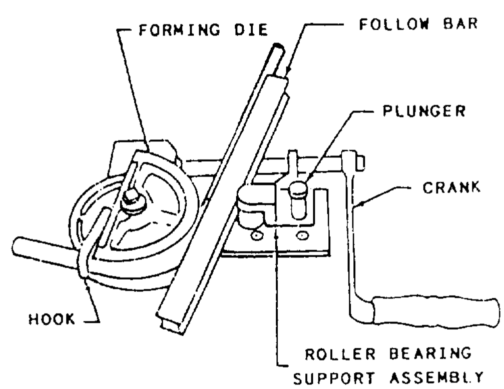


Figure 6-11.—Mechanical operated tube bender.

The simple hand bender shown in figure 6-10 uses two handles as levers to provide the mechanical advantage necessary to bend the tubing, while the mechanical operated tube bender employs a hand crank and gears. The forming die is keyed to the drive gear and secured by a screw (fig. 6-11).

The forming die on the mechanical tube bender is calibrated in degrees similar to the radius block of the hand-type bender. A length of replacement tubing may be bent to a specified number of degrees or it may be bent to duplicate the bend in the damaged tube or pattern. Duplicating the bend of a damaged tube or pattern is accomplished by laying the pattern on top of the tube being bent and slowly bending the new tube to the required bend.

NOTE: Certain types of tubing are more elastic than others. It may be necessary to bend the tube past the required bend to allow for springback.

Before bending aluminum alloy tubing, it should be packed with fusible alloy Federal Specification QQ-F-838. In an emergency, when aluminum alloy QQ-F-838 is not available, aluminum alloy tubing may be packed with shot or sand and both ends closed with protective closures before bending. Where sand or fusible alloy is used, wash or blow out all particles after the tubing has been bent. Particles of aluminum alloy or sand can cause serious damage to component parts.

TUBE JOINT PREPARATION

The two major tube joints are the flared fittings and flareless fittings. Preparation for these tube joints differ.

Flared Fitting

There are two types of flared tubing joints—the single-flared joint and the double-flared joint. The single-flared tube joint is used on all sizes of steel tubing and 5052 aluminum alloy tubing that conforms to Federal Specification WW-T-700/6 with 1/2 inch or larger outside diameter, Use the tube flaring tool (fig. 6-12) to prepare tube ends for flaring. Check tube ends for roundness, square cut, cleanliness, and no draw marks or scratches. Draw marks can spread and split the tube when it is flared. Use a deburring tool to remove burrs from the inside and outside of the tubing. Remove filings, chips, and grit from inside the tube. Clean the tube. Slip the fitting nut and sleeve onto the tube. Place the tube into the proper size hole in the grip die. Make sure the end of the tube extends 1/64 inch above the surface of the grip die. Center the plunger over the end of the tube and

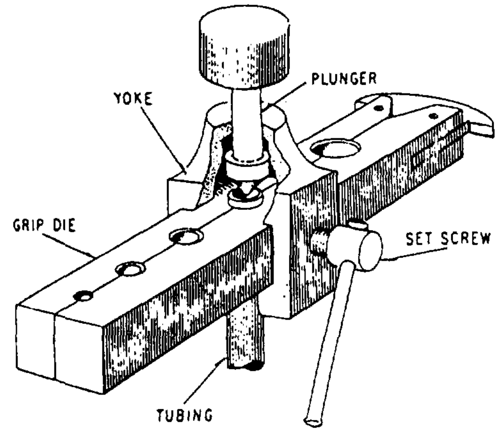


Figure 6-12.—Tube flaring toot (single-flare).

tighten the yoke setscrew to secure the tube in the grip die and hold the yoke in place. Strike the top of the plunger several light blows with a hammer or mallet, turning the plunger a half turn after each blow. Loosen the setscrew and remove the tube from the grip die. Check to make sure that no cracks are evident and that the flared end of the tube is no larger than the largest diameter of the sleeve being used.

The double-flare tube joint is used on all 5052 aluminum alloy tubes with less than 1/2-inch outside diameter, except when used with NAS 590 series tube fittings and NAS 591 connectors or NAS 593 connectors. Aluminum alloy tubing used in low-pressure oxygen systems or corrosion-resistant steel used in brake systems must be double flared. Double flare reduces the chance of cutting the flare by overtightening. When fabricating oxygen lines, make sure that all tube material and tools are kept free of oil and grease. Use the tube flaring tool (fig. 6-13) to prepare tube ends. Check tube end for roundness, square cut, cleanliness, and make sure there are no draw marks or scratches. Draw marks can split the tubing when it is flared.

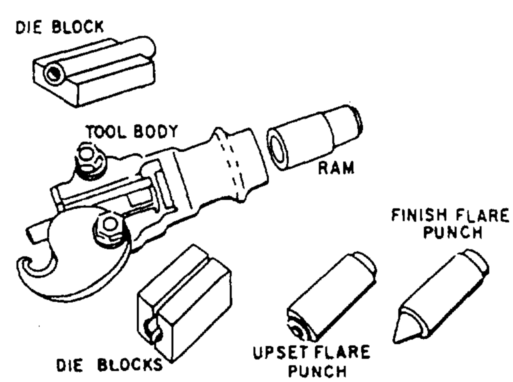


Figure 6-13.—Tube flaring tool (double-flare).

Use a deburring tool to remove burrs from the inside and outside of tube. Remove filings, chips, and grit from inside the tube. Clean the tube. Select the proper size die blocks, and place one-half of the die block into the flaring tool body with the countersunk end towards the ram guide. Install the nut and sleeve, and lay the tube in the die block with 1/2 inch protruding beyond countersunk end. Place the other half of the die block into the tool body, close latch plate, and tighten the clamp nuts fingertight. Insert the upset flare punch in the tool body with the gauge end toward the die blocks. The upset flare punch has one end counterbored or recessed to gauge the amount of tubing needed to form a double lap flare. Insert the ram and tap lightly with a hammer or mallet until the upset flare punch contacts the die blocks, and the die blocks are set against the stop plate on the bottom. Use a wrench to tighten the latch plate nuts alternately, beginning with the closed side, to prevent distortion of the tool. Reverse the upset flare punch; insert the upset flare punch and ram into the tool body. Tap lightly with a hammer or mallet until the upset flare punch contacts the die blocks. Remove the upset flare punch and ram. Insert the finishing flare punch and ram. Tap the ram lightly until a good seat is formed (fig. 6-14). Check the seat at intervals during the finishing operation to avoid overseating.

Flareless Fitting

Preparing tube ends for flareless fitting requires a presetting operation whereby the sleeve is set onto the tubing. Presetting is necessary to form the seal between the sleeve and the tube without damaging the connector. Presetting should always be accomplished with a presetting tool, such as the one shown in figure 6-15. These tools are machined from tool steel and hardened so that they may be used with a minimum of distortion and wear.

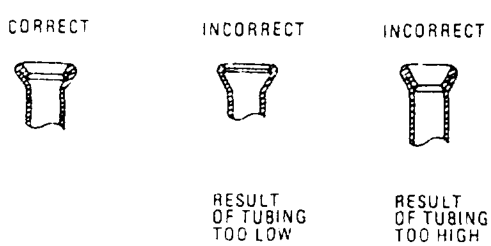


Figure 6-14.—Tube position and resulting flare.

NOTE: A flareless-tube connector may be used as a presetting tool in case of an emergency. However, when connectors are used as presetting tools, aluminum connectors should be used only once, and steel connectors should not be used more than five times.

Special procedures are used in the presetting operation. Select the correct size presetting tool or a flareless fitting body. Clamp the presetting tool or flareless fitting body in a vise. Slide a nut and then a sleeve onto the tube, and make sure the pilot and cutting edge of the sleeve points toward the end of tube. Select the lubricant from table 6-4, and lubricate fitting threads, tool seat, and shoulder sleeve. Place the tube end firmly against the bottom of the presetting tool seat, while slowly screwing the nut onto the tool threads with a wrench until the tube

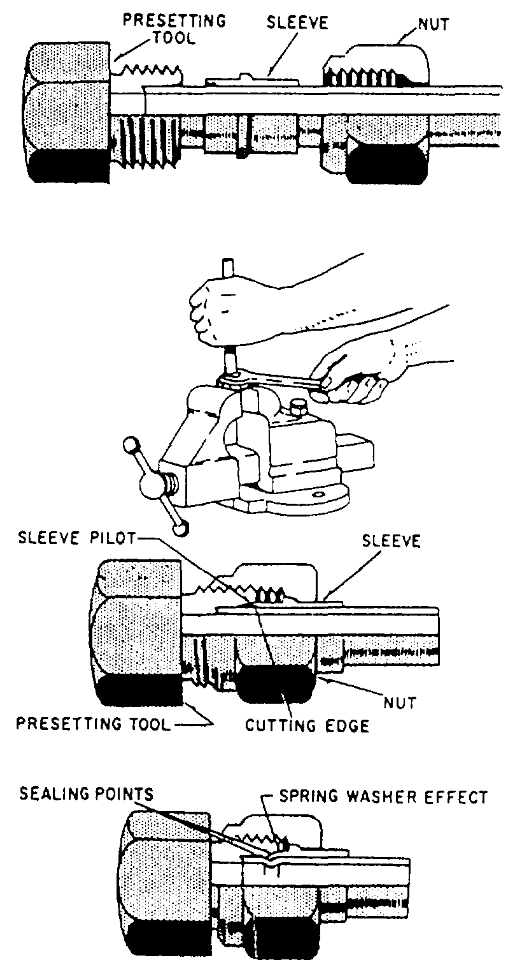


Figure 6-15.—Presetting flareless-tube assembly.

Table 6-4.-Thread Lubricants

SYSTEM	LUBRICANT
Hydraulic	Specification MIL-H-5606
Fuel	Specification MIL-H-5606
Oil	Specification MIL-O-6032 or MIL-L-23699
Freon	Specification MIL-L-6085A
Pneumatic	Specification MIL-G-4343
Oxygen	Specification MIL-T-27730A

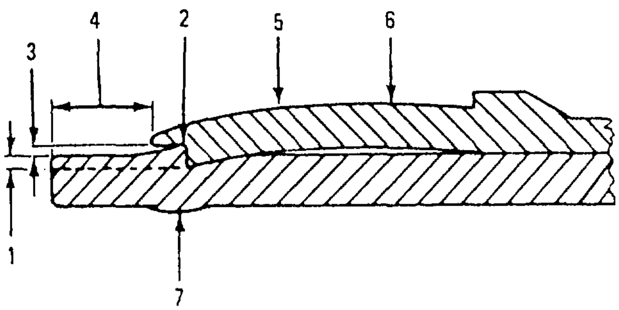


Figure 6-16.—Preset sleeve.

cannot be rotated with thumb and fingers. At this point the cutting edge of the sleeve is gripping the tube and preventing tube rotation; the fitting is ready for the final tightening force needed to set the sleeve on the tube. Tighten the nut to the number of turns specified in *Aviation Hose and Tube Manual*, NAVAIR 01-1A-20.

After presetting, unscrew the nut from the presetting tool or flareless fitting body; check the sleeve and tube (fig. 6-16). Sleeve cutting lip should be imbedded into the tube's outside diameter between 0.003 inch and 0.008 inch, depending on size and tubing material. A lip of tube material will be raised under the sleeve pilot. The sleeve pilot should contact or be quite close to the outside diameter of tube. The tube projection from the sleeve pilot to the tube end should be as listed in table 6-5. The sleeve should be bowed slightly. The sleeve may rotate on tube and have a maximum lengthwise movement of 1/64 inch. The sealing surface of the sleeve, which contacts the

Table 6-5.—Tube Projection From Sleeve Pilot

TUBE SIZE	*APPROXIMATE TUBE PROJECTION-INCHES
2	7/64
3	7/64
4	7/64
5	5/32
6	11/64
8	3/16
10	13/64
12	7/32
16	15/64
20	1/4
24	1/4
32	9/32

*The figures vary upon change of wall thickness for a given size. Do not use these dimensions as an inspection standard but rather as an approximation of proper tube projection.

Table 6-6.—Minimum Inside Diameter of Tubing

TUBE OUTSIDE DIAMETER	6061 ALUMINUM		1/8 HARD STAINLESS		ANNEALED STAINLESS	
	WALL	MIN ID	WALL	MIN ID	WALL	MIN ID
1/8	0.020	0.060	0.016	0.070	0.020	0.060
3/16	0.028	0.095	0.018	0.110	0.020	0.115
1/4	0.035	0.150	0.020	0.165	0.028	0.155
5/16	0.049	0.180	0.022	0.225	0.035	0.225
3/8	0.049	0.240	0.025	0.290	0.049	0.270
1/2	0.065	0.330	0.028	0.400	0.058	0.380
5/8	0.083	0.420	0.035	0.485	0.065	0.475
3/4	0.095	0.530	0.042	0.610	0.083	0.590
1	0.065	0.830	0.065	0.840	0.083	0.800
All measurements are in inches.						

24-degree angle of fitting body seat, should be smooth, free from scores, and should not show lengthwise or circular cracks. Crazing cracks in finish are not harmful to safety or function of fitting. Minimum internal tube diameter should not be less than values shown in table 6-6.

Table 6-7.—Alternate Cleaning Solvents for Tubing and Tube Assemblies

Cleaning Solvents	Specification
Dry Cleaning Solvent	P-D-680
Trichloroethane, 1.1.1	MIL-T-81533
Trichlorotrifluorcethane	MIL-C-81302

CAUTION

Only MIL-C-81302 is approved for cleaning oxygen systems.

PROOF PRESSURE TESTING

Tube assemblies that are fabricated according to the instructions in *Aviation Hose and Tube Manual,* NAVAIR 01-1A-20, should be proof pressure tested to twice the operating pressure of the system in which they are to be installed, provided the operating pressure is greater than 50 psi. Tubing, installed in systems having an operating pressure of less than 50 psi must be proof pressure tested to a minimum of 100 psi. Vent tubes or drain tubes do not require proof pressure testing.

The fluid medium for proof pressure testing of all tube assemblies except oxygen systems should be a liquid medium such as hydraulic fluid, water, or oil. Oxygen tubing should be tested using dry nitrogen and inspected for leaks while the tubing is submerged in water.

CLEANING TUBING AND TUBE ASSEMBLIES

All tubing and tube assemblies must be cleaned after fabrication to prevent contamination of the system in which they will be installed. Dry-cleaning solvent P-D-680, Type II, is the preferred cleaner, but the alternate cleaning solvents in table 6-7 maybe used.

Table 6-8.—Prime and Paint for Tube Assemblies

CATEGORY	DESCRIPTION	*PRIME	PAINT
I	Single tube with separate connectors at each end.	Prime after forming, but before fabrication.	Tube assemblies in categories I, II and III shall be painted after fabrication and before installation, except for assemblies in category III which have been partially primed.
II	Tube assemblies consisting of individual tubes permanently joined by nonseparable fittings such as those assembled by brazing, welding, and swaging and having separable connectors at each free end.	Prime after forming, follow by coating joints with MIL-S-8802 before fabrication.	
III	Single or multiple tube assemblies as in I and II, having one or more free ends which must be subsequently joined permanently to another tube assembly by brazing, welding and swaging during installation.	Prime after forming, follow by coating joints with MIL-S-8802 before fabrication. CAUTION If primer is not compatible to permanent joining process, prime tubing a suitable distance away from affected end.	Partially primed tube assemblies in category III shall have additional primer applied as required followed by coating of all nonsealed-nonseparable joints with MIL-S-8802 before application of paint.
IV	Other tube assemblies not described in I, II or III.	The cognizant rework facility shall specify the required protective finishes.	

*Tubing assemblies in categories I, II, and III in which sleeves or ferrules are used in the separable connections and sleeves or ferrules are fixed in position by deforming one or more numbers, prime up to but not beyond initial point of contact. Tubing for use with flared systems shall be primed to the end of the tube.

Oxygen system tube assemblies require special precautions for cleaning. After fabrication, and testing, clean oxygen tube assemblies in accordance with MIL-STD-1359, using trichlorotrifluoroethane (MIL-C-81302) in a spray gun or vapor degreaser. If a vapor degreaser is not used, tube assemblies must remain in the vapor degreaser until the temperature specified in the manufacturing instructions is reached. Tube assemblies must be blown clean and dried with a stream of clean, dry, water-pumped air.

CAUTION

Oil-pumped air is not a suitable substitute for water-pumped air because it causes oil to be deposited in the tube assemblies. Oxygen reacts violently with oil and may cause equipment damage and injury to personnel. Oxygen (BB-0-925) or clean, dry, water-pumped nitrogen (BB-N-411) must be used in place of water-pumped air. Only MIL-C-81302 is approved for cleaning oxygen system tubing.

PROTECTIVE PAINT FINISH

Tube assemblies that require paint as a protective finish are described in table 6-8. Titanium or stainless steel tubing does not require primer or paint except in areas of dissimilar metals. Primer or paint on

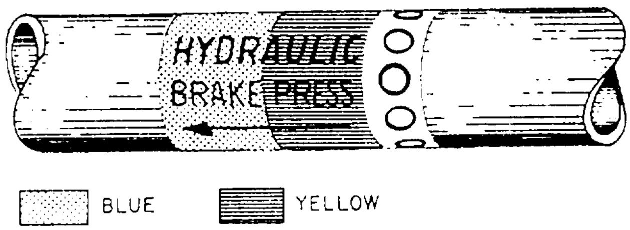


Figure 6-17.—Fluid line identification application.

stainless steel tubing currently installed on naval aircraft need not be removed. The basic reason for this is that cracked or damaged paint systems establish a differential oxygen concentration cell, which may result in tubing corrosion damage.

Do not paint interior surfaces of airspeed indicator tubing, oxygen, or other plumbing lines. Tube assemblies located inside of an aircraft are interior tube assemblies. Tube assemblies located outside of an aircraft are exterior tube assemblies. Interior tube assemblies require a protective finish of two coats of zinc chromate, using application techniques as specified in *Aircraft Weapons System Cleaning and Corrosion Control,* NA 01-1A-509. Protective finishes for exterior tube assemblies should be the same as for exterior aircraft surfaces specified in NA01-1A-509.

IDENTIFICATION

Fabricated tube assemblies should be identified before installation or storage. All information from the identification tag of the removed tube assembly should be transferred to the tag on replacement tube assembly. Identify the tube assemblies by ink stamping or stenciling the part number, manufacturer's code, and other required data on tube assemblies. Apply a protective coat of clear varnish over the markings. To aid in the rapid identification of the various tubing systems and operating pressure, each fluid line in the aircraft is identified by bands of paint or strips of tape around the line near each fitting. These identifying media are applied at least once in each compartment. Various other information is also applied to the lines.

Identification tapes are applied to all lines less than 4 inches in diameter except cold lines, hot lines, lines in oily environment, and lines in engine compartments where there is a possibility of the tape being drawn into the engine intake. In these cases, and all others where tapes should not be used, painted identification is applied to the lines.

Identification tape codes indicate the function, contents, hazards, direction of flow, and pressure in the fluid line. These tapes are applied in accordance with MIL-STD-1247C. This military standard was issued to standardize fluid line identification throughout the Department of Defense. Figure 6-17 shows the method of applying these tapes as specified by this standard.

The function of a line is identified by use of a tape, approximately 1 inch wide, upon which word(s), color(s), and geometric symbols are printed. Functional identification markings, as provided in MIL-STD-1247C, are the subject of international standardization agreements. Three-fourths of the total width on the left side of the tape has a code color or colors that indicate one function only per color or colors. The function of the line is printed in English across the colored portion of the tape. Even a non-English-speaking person can troubleshoot or maintain the aircraft if he/she knows the code but cannot read English. The right-hand one-fourth of the functional identification tape contains a geometric design rather than the color(s) or word(s). Figure 6-18 is a listing, in tabular form, of functions and their associated identification media as used on

FUNCTION	COLOR	SYMBOL
Fuel	Red	
Rocket Oxidizer	Green, Gray	
Rocket Fuel	Red, Gray	
Water Injection	Red, Gray, Red	
Lubrication	Yellow	
Hydraulic	Blue, Yellow	
Solvent	Blue, Brown	
Pneumatic	Orange, Blue	
Instrument air	Orange, Gray	
Coolant	Blue	
Breathing Oxygen	Green	
Air Conditioning	Brown, Gray	
Monopropellant	Yellow, Orange	
Fire Protection	Brown	
De-Icing	Gray	
Rocket Catalyst	Yellow, Green	
Compressed gas	Orange	
Electrical Conduit	Brown, Orange	
Inerting	Orange, Green	

Figure 6-18.—Functional identification type data.

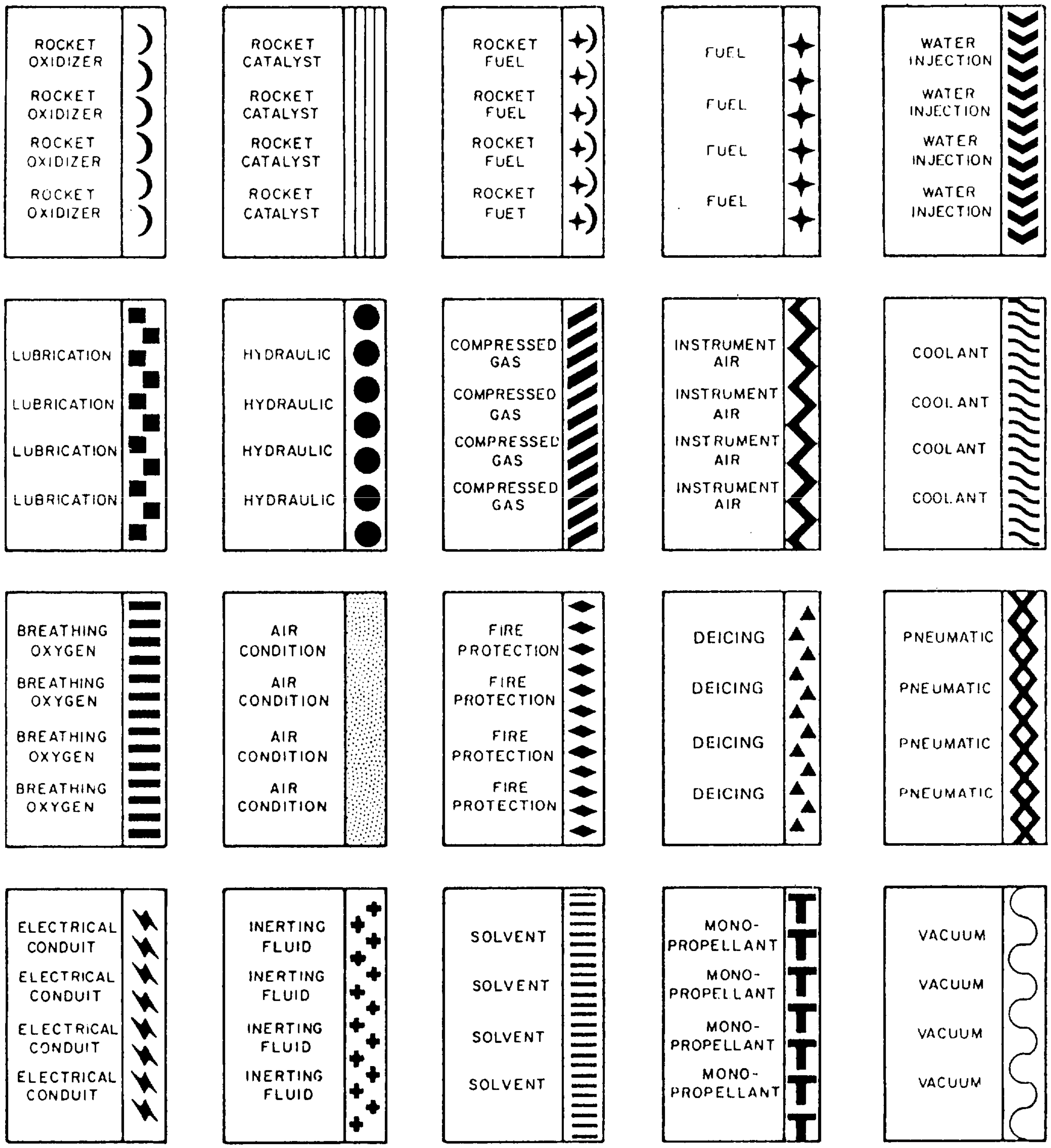
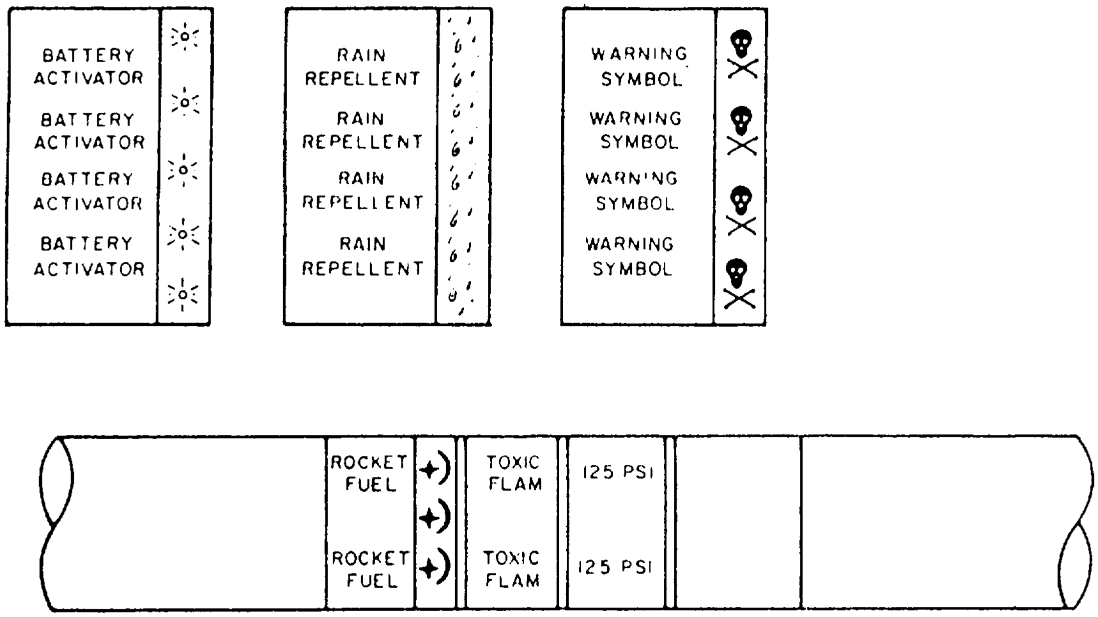


Figure 6-19.—Color-coded functional identification tapes.

the tapes Figure 6-19 shows the different tapes used in identifying tubing.

The identification-of-hazards tape shows the hazard associated with the contents of the line. Tapes used to show hazards are approximately 1/2 inch wide, with the abbreviation of the hazard contained in the line printed across the tape. There are four general classes of hazards found in connection with fluid lines. These hazards are outlined in the following text:

- Flammable material (FLAM). The hazard marking FLAM is used to identify all materials



NOTES:

1. THE ABOVE COLOR CODES REPRESENT DESIGNATION FOR SYSTEMS ONLY. FOR CODING LINES WHICH DO NOT FALL INTO ONE OF THESE SYSTEMS, THE CONTENTS SHALL BE DESIGNATED BY BLACK LETTERING ON A WHITE TAPE.
2. SUBSIDIARY FUNCTIONS OR IDENTIFICATION OF LINE CONTENT MAY BE INDICATED BY THE USE OF ADDITIONAL WORDS OR ABBREVIATIONS WHICH SHALL BE CARRIED ON A SECOND TAPE ADJACENT TO THE FIRST OR ALTERNATIVELY, INTERPOSED BETWEEN THE WORDS DESCRIPTIVE OF THE MAIN FUNCTION.
3. WARNING SYMBOL TAPES, 3/8 INCH WIDE, SHALL BE APPLIED TO THOSE LINES WHOSE CONTENTS ARE CONSIDERED TO BE DANGEROUS TO MAINTENANCE PERSONNEL. WARNING TAPES ARE TO BE PLACED ADJACENT TO SYSTEM IDENTIFICATION TAPES.
4. ONE BAND SHALL BE LOCATED ON EACH TUBE SEGMENT, 24 INCHES OR SHORTER. ONE BAND SHALL BE LOCATED AT EACH END OF EACH TUBE SEGMENT LONGER THAN 24 INCHES. ADDITIONAL BANDS SHALL BE APPLIED WHEN THE TUBE SEGMENT PASSES THROUGH MORE THAN ONE COMPARTMENT OR BULKHEAD. AT LEAST ONE BAND SHALL BE VISIBLE IN EACH COMPARTMENT OR ON EACH SIDE OF THE BULKHEAD.
5. PRESSURE TRANSMITTER LINES SHALL BE IDENTIFIED BY THE SAME COLORS AS THE LINES FROM WHICH THE PRESSURE IS BEING TRANSMITTED.
6. FILLER LINES, VENT LINES AND DRAIN LINES OF A SYSTEM SHALL BE IDENTIFIED BY THE SAME COLORS AS THE RELATED SYSTEM.

CAUTION

TAPES SHALL NOT BE USED ON FLUID LINES IN THE ENGINE COMPARTMENT WHERE THERE IS A POSSIBILITY OF THE TAPE BEING DRAWN INTO THE ENGINE INTAKE. FOR SUCH LOCATIONS, SUITABLE PAINTS, CONFORMING TO THIS COLOR CODE, AND WHICH HAVE NO HARMFUL EFFECT ON THE MATERIAL USED FOR THE LINES, SHALL BE USED FOR IDENTIFICATION PURPOSES. IN THESE CASES, THE GEOMETRICAL SYMBOLS MAY BE OMITTED.

Figure 6-19.—Color-coded functional identification tapes—Continued.

known ordinarily as flammables or combustibles.

- Toxic and poisonous materials (TOXIC). A line identified by the word TOXIC contains materials that are extremely hazardous to life or health.

- Anesthetics and harmful materials (AAHM). All materials productive of anesthetic vapors and all liquid chemicals and compounds hazardous to life and property, but not normally productive of dangerous quantities of fumes, or vapors, are in this category.

- Physically dangerous materials (PHDAN). A line that carries material that is not dangerous within itself, but that is asphyxiating in confined areas or is generally handled in a dangerous physical state of pressure or temperature, is identified by the marking PHDAN.

Table 6-9 lists some of the fluids with which you may be required to work and the hazards associated with each one.

For convenience in distinguishing one hydraulic line from another, each line is designated as to its function within the system. In general, the various hydraulic lines are designated as follows:

Supply lines. Lines that carry fluid from the reservoir to the pumps are called supply (or suction) lines.

Pressure lines. Lines that carry only pressure are called pressure lines. Pressure lines lead from the pumps to a pressure manifold, and from the pressure manifold to the various selector valves, or they may run directly from the pump to the selector valve.

Operating lines. Lines that alternately carry pressure to an actuating unit and return fluid from the actuating unit are called operating lines, or working lines. Each operating line is identified in the aircraft according to its specific function; for example, LANDING GEAR UP, LANDING GEAR DOWN, FLAPS UP, FLAPS DOWN, etc., as the case may be.

Return lines. Lines that are used to return fluid from any portion of the system to the reservoir are called return lines.

Vent lines. Lines that carry excess fluid overboard or into another receptacle are called vent lines.

Table 6-9.—Hazards Associated with Various Fluids

Contents	Hazard
Air (under pressure)	PHDAN
Alcohol	FLAM
Carbon dioxide	PHDAN
Freon	PHDAN
Gaseous oxygen	PHDAN
Liquid nitrogen	PHDAN
Liquid oxygen	PHDAN
LPG (liquid petroleum gas)	FLAM
Nitrogen gas	PHDAN
Oils and greases	FLAM
JP-5	FLAM
Trichlorethylene	AAHM

STORAGE

Fabricated tubing and tube assemblies requiring storage for any length of time should be provided with protective closures at each end.

Do not use pressure-sensitive tape as a substitute for protective closures. Oxygen tube assemblies require protection of the entire assembly in addition to protective closures at end fittings. The complete assembly should be stored and packaged in sealed plastic bags in accordance with *Aviation Crew Systems Manual Oxygen Equipment,* NA 13-1-6.4.

TUBING AND TUBE ASSEMBLIES MAINTENANCE

Learning Objective: *Recognize the maintenance practices and procedures used in the repair and fabrication of tubing and tube assemblies.*

Maintenance of tube assemblies at the organizational level is limited to inspection, removal, installation, repair and replacement. Inspections are performed during fabrication, installation, and on in-service equipment. During fabrication, inspect bulk tubing and fittings before and during fabrication of a tube assembly. Before replacing a defective tube assembly, find the cause of failure, and inspect the tube assembly before and after its installation. Inspect in-service tube assemblies at regular intervals in accordance with applicable maintenance directives. When you inspect the tube and tube assemblies for damage, look for chafing, galling, or fretting, which may reduce the ability of tubing to withstand internal pressure and vibration. Replace tubing that shows visible penetration of the tube wall surface caused by chafing, galling, or fretting. Tubes that have damage (nicks, scratches, or dents) caused by careless handling of tools are acceptable if they meet the following requirements: Any dent that has a depth less than 20 percent of the tubing diameter is acceptable unless the dent is on the heel of a short bend radius. A nick or scratch that has a depth of less than 15 percent of the wall thickness of aluminum, aluminum alloy, or steel tubing should be reworked by burnishing with hand tools before it is acceptable. Any aluminum, aluminum alloy, or steel tubing carrying pressures greater than 100 psi with nicks or scratches greater than 15 percent of wall thickness should be replaced.

Inspect each fitting (fig. 6-20) before it is installed. Visually or flow check to make sure that fitting passage or passages are free from obstructions.

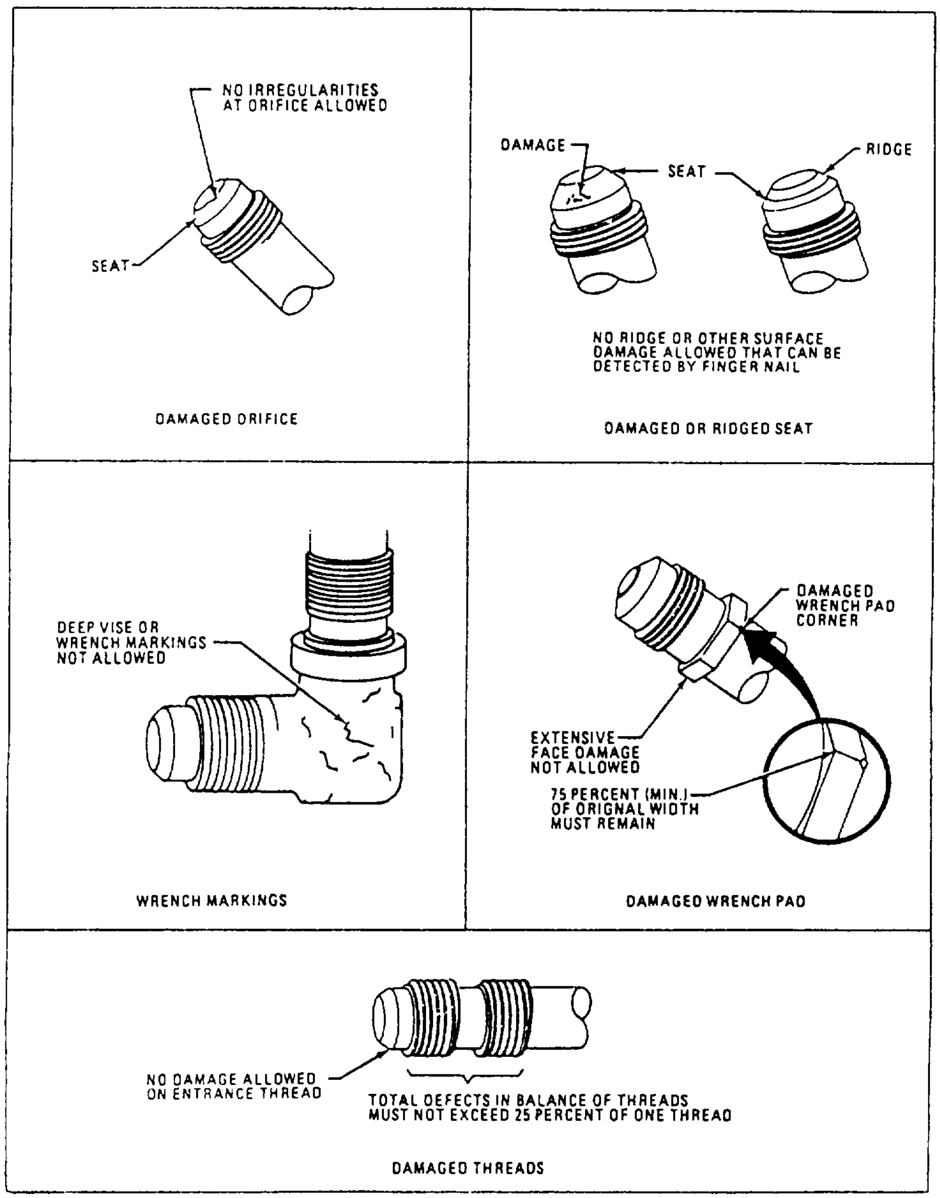


Figure 6-20.—Damaged fittings.

INSTALLATION

Installation of tube assemblies involves a preinstallation check before tube assemblies can be installed. Before you install tube assemblies, check to make sure there are no dents, nicks, and scratches; that the assembly contains the correct nuts and sleeves; that there is a proper fit, where fitting is flared; that a proof pressure test is performed on each assembly; and that the assemblies are clean.

To install tube assemblies, hand screw the nuts onto mating connectors. Align the tube assembly in place so that it will not be necessary to pull it into place with the nut. Tubing that runs through cutouts should be installed to avoid scarring when the tubing is worked through a hole. If the tube assembly is long, tape the edge of cutouts before installing the assembly. Torque the nuts. Apply a protective coating to the remaining nonsealed joints after tubing is installed. For disconnected nonsealed joints, apply MIL-S-8802, followed by appropriate paint system, if required. For connected nonsealed joints, apply the first coat of MIL-C-16173, grade 4; 1 hour after applying the first coat, apply the second coat of MIL-C-16173, grade 4. Correct and incorrect methods of installing flared tube assemblies are shown in figure 6-21.

Leakage of a flared tube assembly is usually caused by the following:

- Flare distorted into the nut threads.
- Sleeve cracked.
- Flare out of round.
- Flare cracked or split.
- Inside of flare rough or scratched.
- Connector mating surface rough or scratched.
- Connector threads or nuts are dirty, damaged, or broken.

If an aluminum alloy flared tube assembly leaks after it has been tightened to the required torque, disassemble it for repair or replacement. If a steel flared tube assembly leaks, it may be tightened one-sixteenth turn beyond the noted torque. If the assembly continues to leak, it should be disassembled for repair or replacement. Do not tighten a nut when there is pressure in the line. Do not overtighten a leaking aluminum alloy assembly. Overtightening may severely damage or cut off tubing flare, or damage sleeve or nut.

When you install flareless tube assemblies, proceed as follows: Make sure no nicks or scratches are evident and the sleeve is preset. Tighten the nut

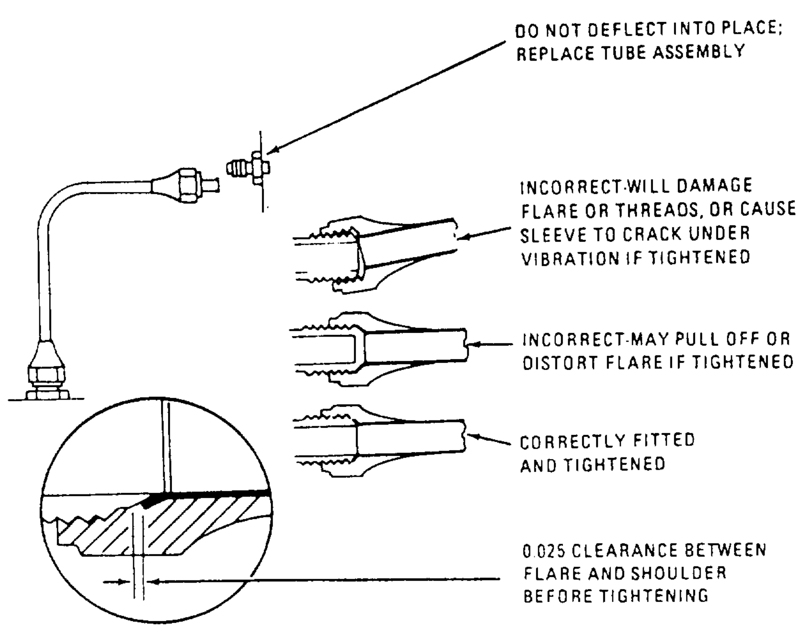


Figure 6-21.—Correct and incorrect methods of installing flared fittings.

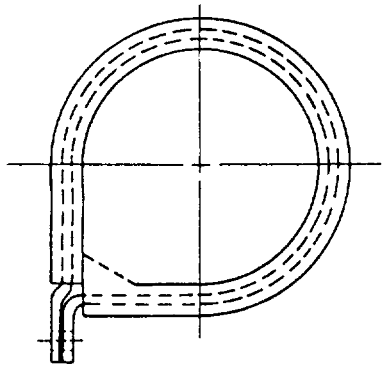


Figure 6-22.—Cushioned steel clamp MIL-C-85052.

by hand until resistance to turning develops. If it is impossible to use fingers to run nut down, use a wrench. Look out for the first signs of bottoming. Do not use pliers to tighten tube connectors.

Final tightening should begin at the point where the nut begins to bottom. Use a torque wrench if fitting is accessible and torque fitting. If a connection is not accessible for torque wrench, use a wrench to turn nut one-sixth turn while holding the connector with another wrench to prevent the connector from turning. A one-sixth turn equals the travel of one flat on a hex nut. Tighten nut an additional one-sixth turn if the connector leaks. Do not tighten fitting nut more than one-third of a turn (two flats on nuts). Loosen and completely disconnect the nut if the leak continues. Inspect fitting components for scores, cracks, foreign material, or damage from previous overtightening. Reassemble fitting. Fingertighten nut and repeat wrench tightening. It is important to tighten tube fitting nuts properly. A fitting wrench or an open-end wrench should be used when tightening connections.

All hydraulic tubing should be supported from rigid structures by cushioned steel clamps MIL-C-85052 or multiple tube block clamps. See figure 6-22. Hydraulic tubing support clamps should be installed and maintained in the positions described in the MIM or applicable technical directives.

Unless otherwise specified, where tubing is supported to structure or other rigid members, a minimum clearance of 1/16 inch or where related motion of adjoining components exists, a minimum clearance of 1/4 inch is to be maintained. Table 6-10 shows the maximum allowable distance between

Table 6-10.—Maximum Distance Between Supports for Aluminum Tubing

TUBING OUTSIDE DIAMETER (INCHES)	DISTANCE BETWEEN SUPPORTS IN INCHES	
	ALUMINUM ALLOY	STEEL
1/8	9-1/2	11-1/2
3/16	12	14
1/4	13-1/2	16
5/16	15	18
3/8	16-1/2	20
1/2	19	23
5/8	22	25-1/2
3/4	24	27-1/2
1	26-1/2	30-1/2
1-1/4	28-1/2	31-1/2
1-1/2	29- 1/2	32-1/2

supports. Flexible grommets or hose should be used at points where the tubing passes through bulk-heads.

REPAIR

Tube repair is divided into two categories—temporary and permanent. Temporary repairs are made with splice sections fabricated with flared ends or preset MS sleeves. The splice sections are to be replaced by a permanent repair or new tubing assembly at the next rework cycle. Temporary or emergency repairs should be limited to cases that are due to unavailability of equipment, material, or unusual circumstances.

Cut and remove the damaged section of tubing. Remove the rough edges of the remaining tube ends. Clean the tubing ends with a lint-free wiping cloth. Position the AN818 nuts and AN819 sleeves on the tubing ends (fig. 6-23). Flare the tubing. Install AN815 unions. Position the AN818 nuts and AN819 sleeves on the new section. A new section is not required when the length of the union is longer than the damaged section. Install the new section of tubing and tighten the AN818 nuts. Permanent repairs include removal of minor damage on tubing and fittings and the replacement of line sections or fittings by Permaswage or Dynatube swaging equipment, or by induction brazing.

NOTE: Induction brazing is limited to depot-level repair. Tube assemblies used for engine-related hydraulic, fuel, oil, vent or drain lines usually have brazed or welded end fittings. These engine-related tube assemblies are normally fabricated from corrosion-resistant steel.

Some minor surface damages to tubing are acceptable, as described in inspection of tubing damage. A nick that is not deeper than 15 percent of the wall thickness of aluminum, aluminum alloy, or corrosion-resistant steel is acceptable after being reworked by burnishing with hand tools. Minor damage to fittings is defined as

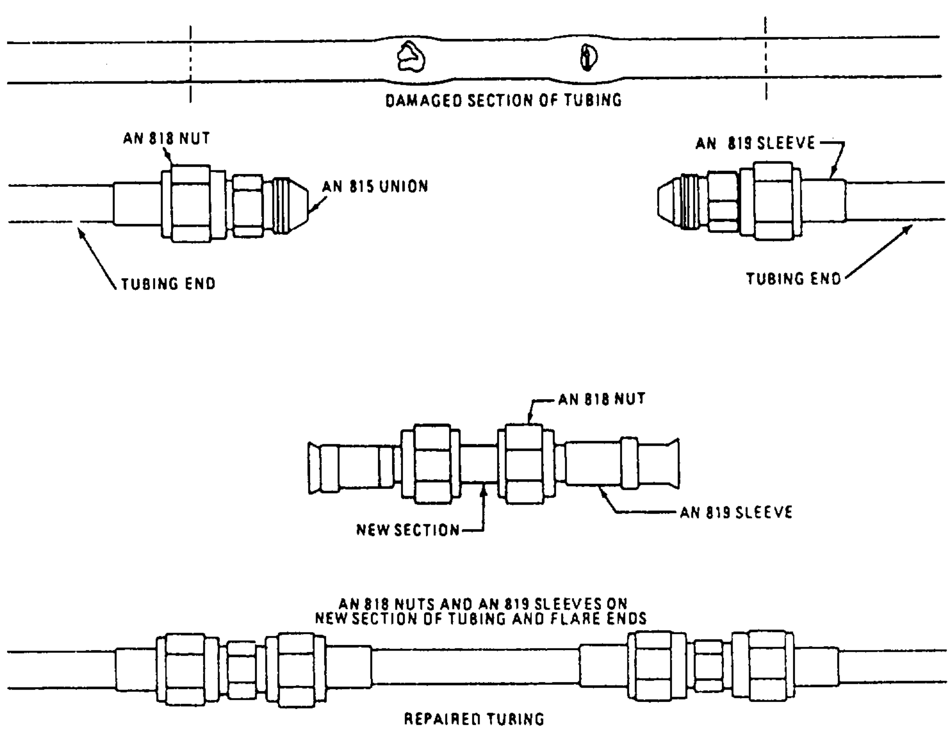


Figure 6-23.—Temporary tubing repair.

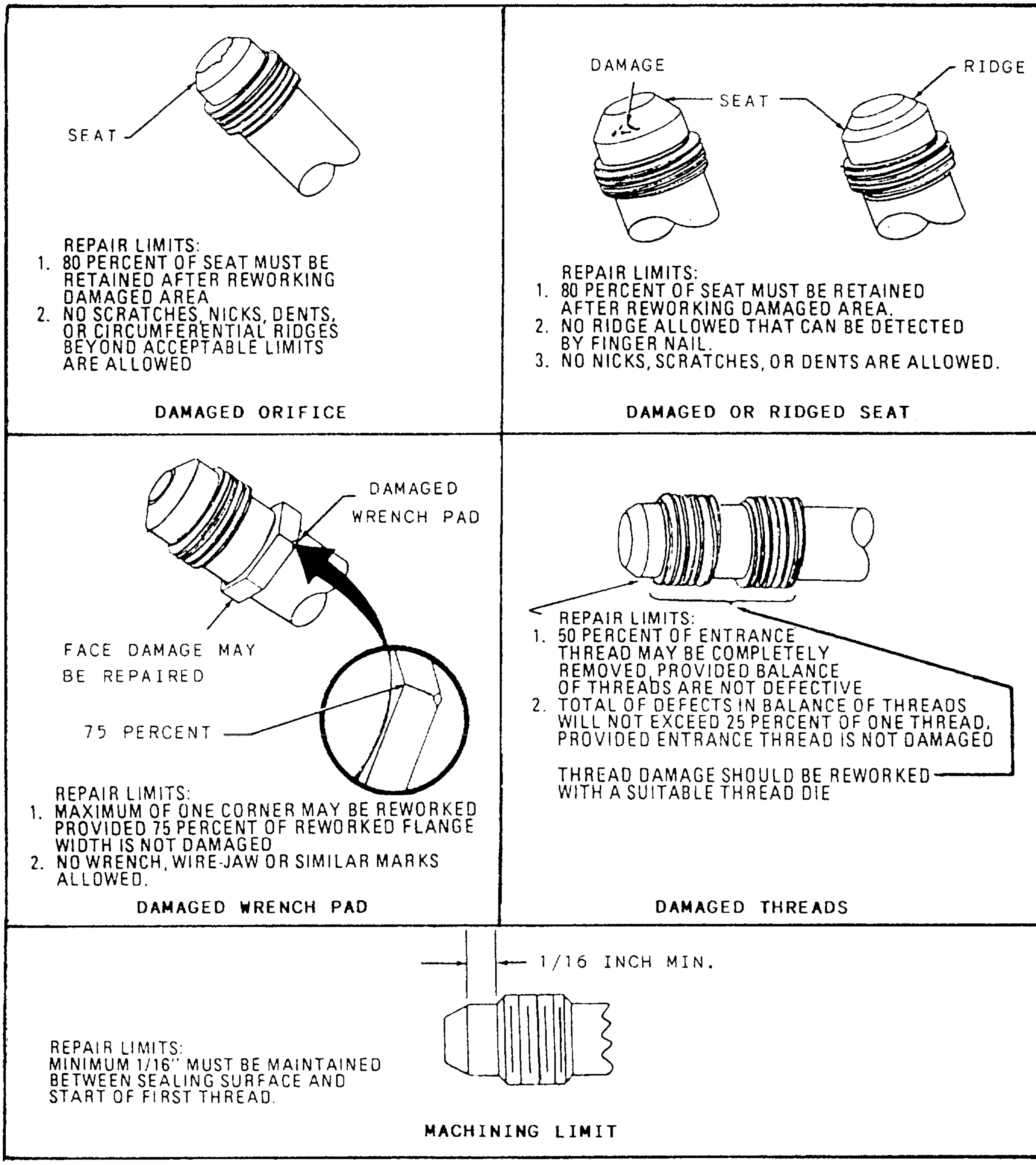
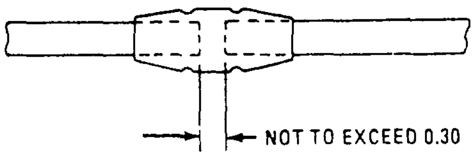
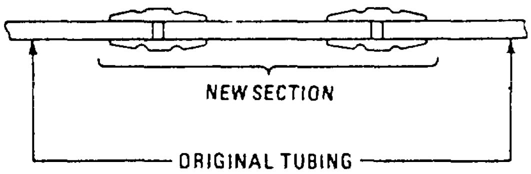
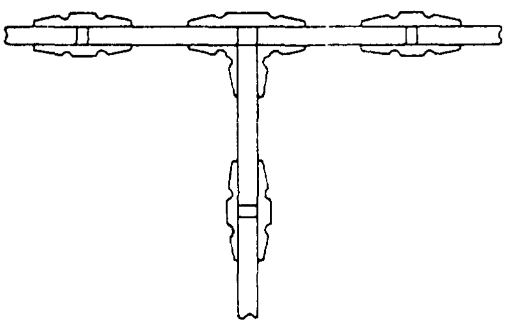
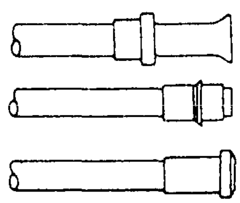


Figure 6-24.—Reworking damaged fittings.

damage not to exceed repairable limits, as shown in figure 6-24.

Fittings that exceed repairable limits should be replaced. To repair damaged fittings, proceed as follows: To repair damaged orifices, remove any restriction in the orifice and handstone it to blend rough edges or burrs, as shown in view A of figure 6-24. To repair damaged or ridged seats, resurface circumferential ridges with annular tool, as shown in view B of figure 6-24. Tool marks other than those of annular tools (one ten-thousandth of an inch RMS) are permitted on sealing surface. Damaged wrench pads are repaired by removing minor scratches with a

Table 6-11.—Tube Assembly Failures and Recommended Repair Methods

TYPE OF FAILURE	REPAIR METHOD
1. Pin hole leak or circumferential crack in tubing. 	1.a. Make 1 or 2 cuts as necessary, to remove damaged section. If 2 cuts are required, the distance between them shall not exceed 0.30 inch. If distance is more than 0.30 inch, go to repair method 2. b. Swage 1 tube to tube union in tube section under repair.
2. Longitudinal crack in tubing (crack length in excess of 0.30 inch). 	2.a. Make 2 cuts to enable removal of damaged section. b. Remove damaged section and duplicate. c. Swage replacement section into tubing under repair using 2 tube to tube unions.
3. Leaking tee or elbow (permanent tube connection type). 	3.a. Cut out defective tee or elbow. b. Duplicate tubing sections for each branch. c. Swage splice sections to tee or elbow. d. Connect each splice section to tubing under repair using a tube to tube union.
4. Leaking flared, flareless or lipseal end fittings. 	4.a. Cut tubing to remove defective fitting. b. Swage appropriate end fitting to tube end. c. Connect new end fitting to mating connection, torquing nut as required.

fine file, leaving no file marks, as shown in view C of figure 6-24. Resurface the 37-degree sealing surface. A minimum distance of 1/16 inch (.063) should be maintained between the 37-degree sealing surface and the start of the first thread (view E of fig. 6-24).

All reworked fittings should be inspected and treated against corrosion. Reworked aluminum alloy fittings should be anodized; however, uniform color of reworked fittings after anodizing is not necessary.

Permaswage Fitting Repair

The basic element of the Permaswage repair technique is the Permaswage fitting, which is mechanically swaged onto the tube by a hydraulically operated tool. Permaswage fittings are designed for use by all levels of maintenance, and are available in various configurations. Tube assembly repair using Permaswage fittings and techniques is considered permanent repair.

Four basic types of tube assembly failures lend themselves to permanent repair using Permaswage fittings and techniques. Each type of tube assembly failure and its recommended repair is described in table 6-11.

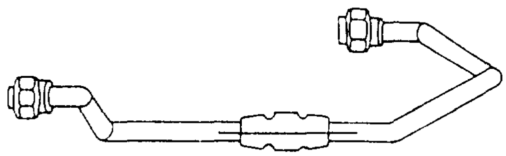


Figure 6-25.—Marking tube.

Before you cut a tube, use a marking pen and a ruler to draw a line parallel to the tube run across the section to be cut (fig. 6-25). Cut the tubing. If a tube end is to be replaced, make sure the line is placed in the same location on the new tube as on the tube section that has been removed. Draw a line across the fitting. Install the tube run and locate the fitting. Fingertighten any end fittings. One end of the fitting may be swaged on the bench if possible. Place the swaging tool on the first end being swaged, and line up the line on the tube end being swaged with the line on fitting. Repeat the procedure with the other ends to be swaged. Torque the fittings.

In addition to the four types of repairs described in table 6-11, flared, flareless, and lipseal end fittings may often be repaired by replacing defective end fittings with Permaswage fittings.

Permaswage tube repair equipment consists of two series, D10000 and D12200. Each series has three separate tool kits and a hydraulic power supply. Installation of fittings by use of either series depends upon the size of fittings, pressure rating, and access to damaged area.

The series D12200 and series D10000 tool kits differ only in the range of tube sizes that each kit can swage. Figure 6-26 illustrates a typical series D10000 tool kit. Series D10000 swaging tools make permanent tubing joints by swaging Permaswage fittings onto compatible tubing. The fittings may be unions, tees, crosses, separable fittings, reducer fittings, and other special fittings.

Hydraulic pressure supplied by a portable hydraulic power supply (fig. 6-27) causes die segments contained within the swaging tool (fig. 6-28) to swage. The basic swage tool assembly contains the actuating piston and a locking latch, which ensures upper die block retention during the swage cycle. The swaging tool is designed to operate over a range of tubing sizes and types of fittings by changing die block assemblies and/or fitting locators. The die block assemblies are supplied in sets, consisting of upper and lower die blocks, dies, and locators. The lower die block is retained on the basic swage tool assembly to make sure of automatic retraction and consistent repeatability. The upper die block assembly is removable for easy loading.

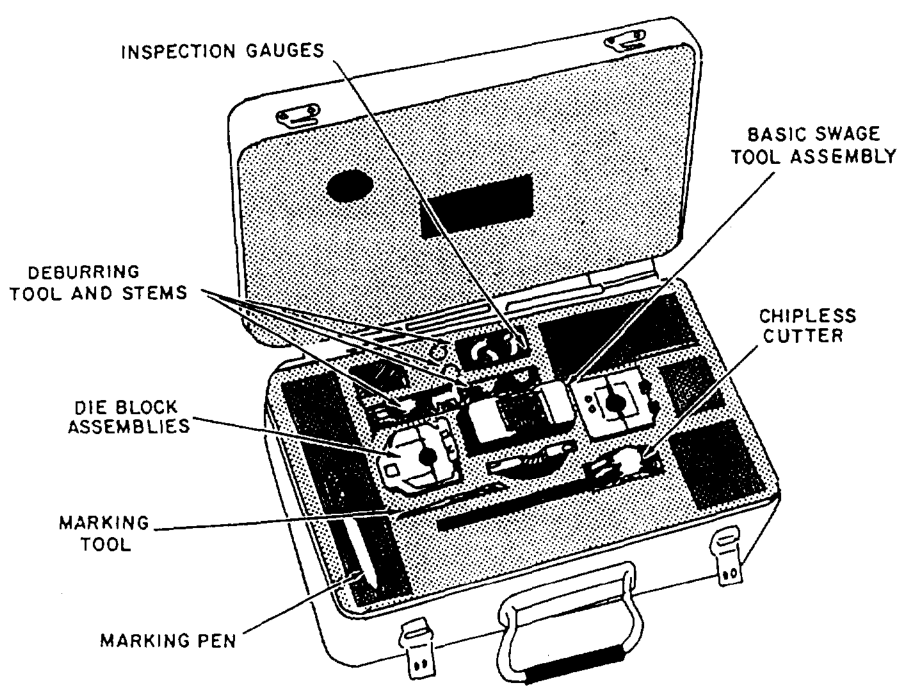


Figure 6-26.—Permaswage Tool Kit D10031-812S.

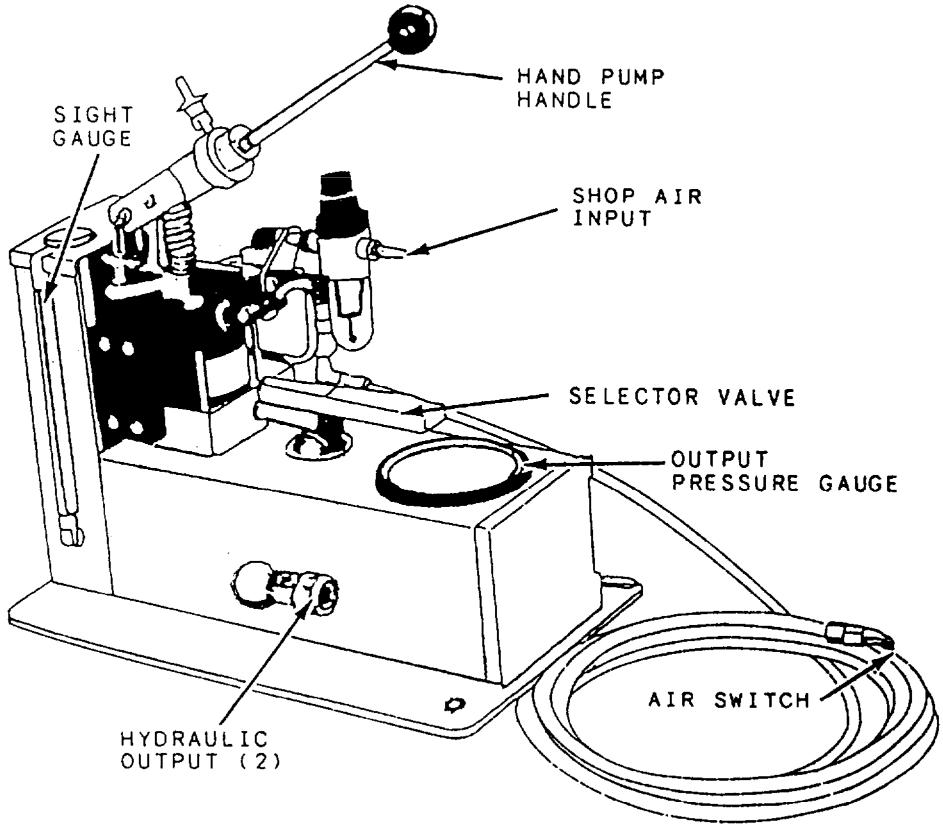


Figure 6-27.—D10004 Permaswage hydraulic power supply.

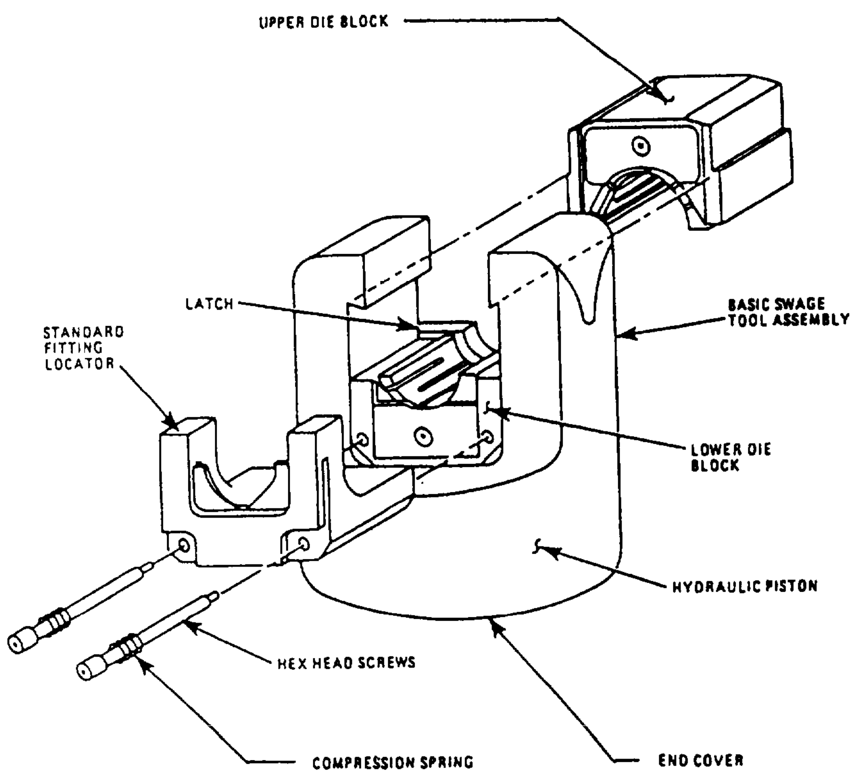


Figure 6-28—Basic swage tool assembly.

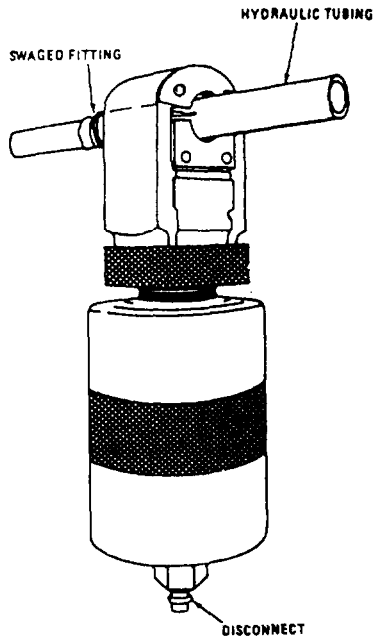


Figure 6-29.—Series D12200 kit swage tool operation.

As a supplement to the series D10000 tool kits, the series D12200 tool kits (fig. 6-29) may be used. The newer type of tooling is smaller in size and is designed to repair tubing on board aircraft.

The portable hydraulic power supply D10004 (fig. 6-27) generates 5,500 psi to operate the swaging tool. Hydraulic fluid is fed to the tool through a 1/4-inch quick-disconnect, high-pressure hose. As a precaution against premature tool fatigue, the swaging pressure is kept from exceeding 5,500 psi by the pressure relief valve. The D 10004 hydraulic power supply can be operated either manually by using a hand pump or automatically by air-to-hydraulic fluid intensification from a 80 ±20 psi pressure shop air source.

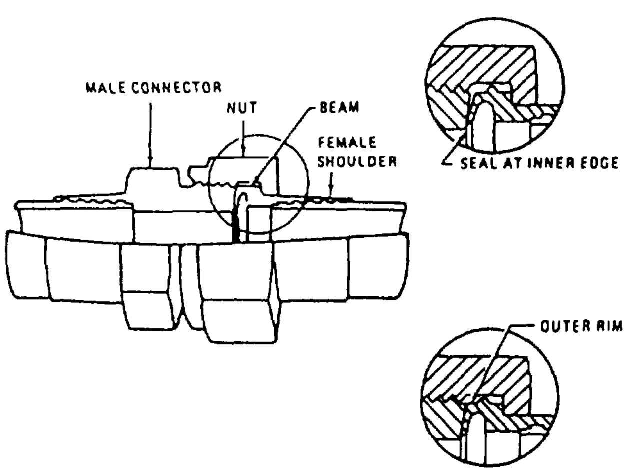


Figure 6-30.—Dynatube fitting.

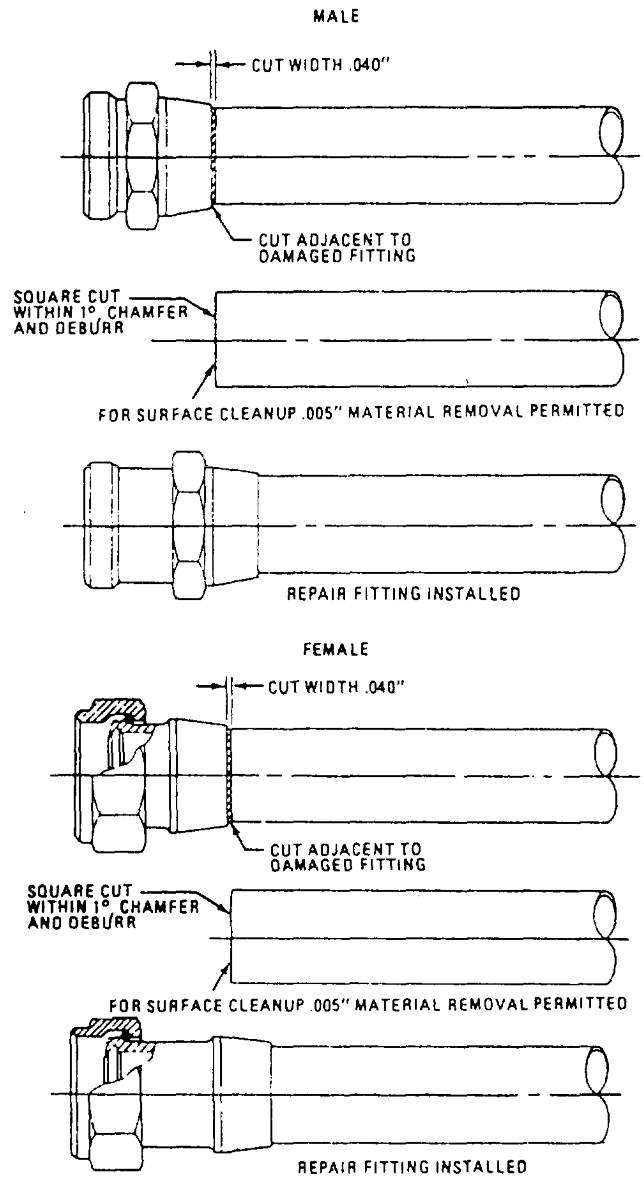


Figure 6-31.—Male and female repair fitting installation.

Dynatube Fitting Repair

Dynatube fittings consist of a threaded male connector, a female shoulder with a machined beam, and a nut (fig. 6-30). Compared to the five components in a standard MS fitting, the three components in a Dynatube fitting are smaller, lighter, and have fewer potential leak paths. Dynatube fittings can be connected to rigid tubing by welding, but internal mechanical swaging with Resistoflex

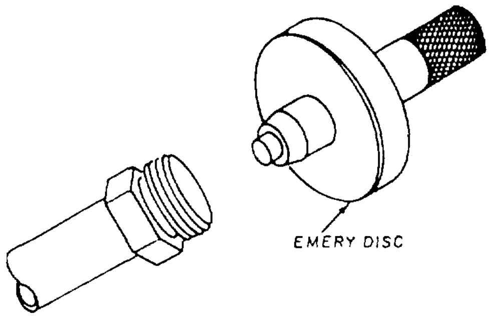


Figure 6-32.—Dynatube fitting resurfacing tool.

hand tools is the authorized method for Navy personnel.

The repair methods using Dynatube fittings are discussed in this section and illustrated in figures 6-31 through 6-33.

One method of repairing damaged Dynatube fittings is to use longer length Dynatube fittings. These can be installed in place of damaged fittings on the same tube assembly, as shown in figure 6-31. Dynatube male fittings with minor surface damage such as scratches can be repaired using the Dynatube fitting resurfacing tool, shown in figure 6-32.

Do not attempt to repair a damaged female Dynatube fitting. Damaged straight tubing can be repaired by cutting out the damaged section and installing a splice assembly in its place, as shown in figure 6-33.

Resistoflex hand tools are housed in a single carrying case (fig. 6-34). These tools are designed for in-place repairs. Figure 6-35 shows tools assembled

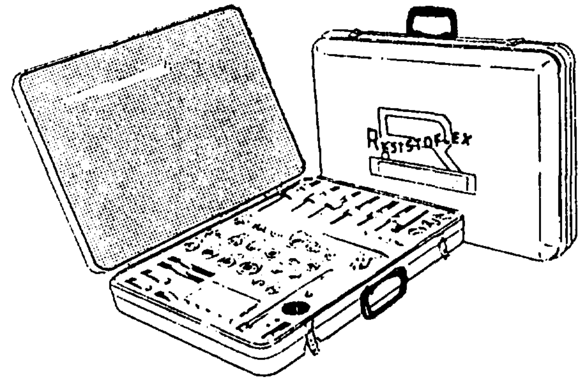


Figure 6-34.—Field installation and repair tool kit.

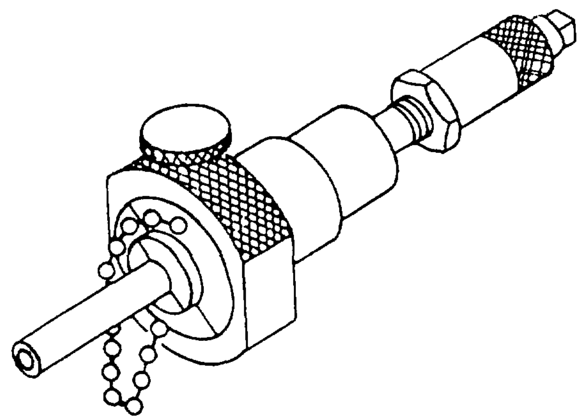


Figure 6-35.—Dynatube swaging process.

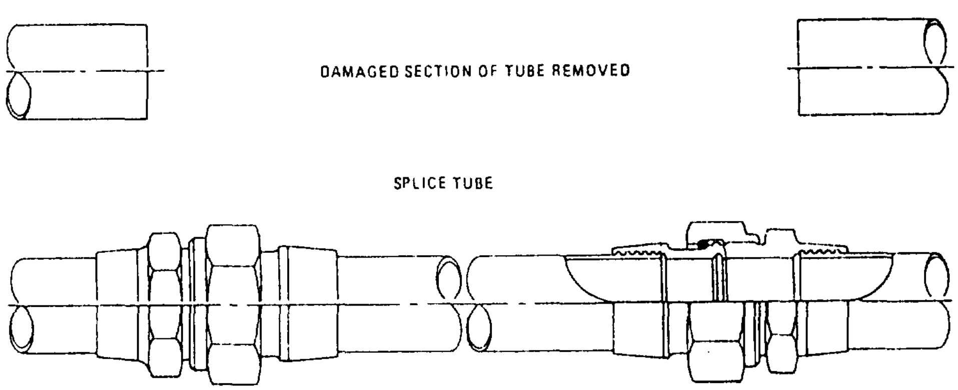


Figure 6-33.—Splice assembly repair.

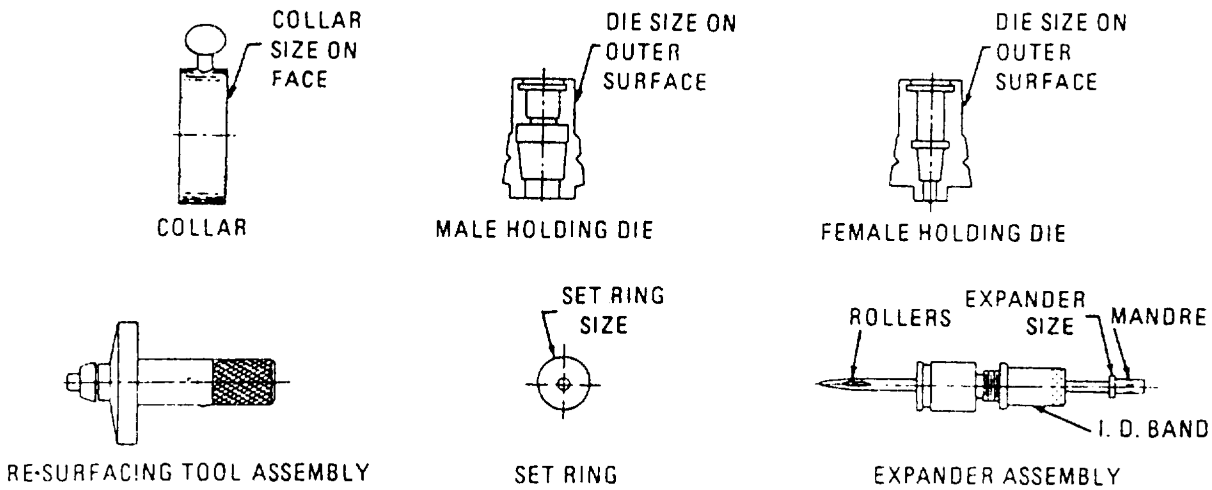


Figure 6-36.—Field installation and repair tool kit.

for swaging process. Some of the tools used to swage fitting are shown in figure 6-36.

Tube expanders are precision swaging tools for expanding hydraulic tubing into serrations of Dynatube fitting sockets. Tube expanders are set to expand tubing to a specific diameter, and must be used only with the tube and wall thickness stated on the tool identification band.

Holding fixture dies support and position Dynatube fittings during swaging. Holding fixture dies have a nest that conforms to the shape and size of the fitting to be used. A male and female set of dies is provided for each basic tube diameter size that corresponds with male or female Dynatube fittings. Holding fixture collars are used to clamp holding fixture dies shut during swaging. The resurfacing tool assembly uses replaceable energy discs in progressively finer grades to remove scratches from the sealing surface of male fittings.

RECOMMENDED READING LIST

NOTE: Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. Therefore, you need to be sure that you are studying the latest revision.

Fluid Power, NAVEDTRA 12964, Naval Education and Training Program Management Support Activity, Pensacola, Florida, July 1990.

Naval Aviation Maintenance Program, OPNAVINST 4790.2 (series), Office of the Chief of Naval Operations, Washington, D.C.

Aviation Hose and Tube Manual, NAVAIR 01-1A-20, Naval Air Systems Command, Washington, D. C., June 1989.

Aviation Hydraulics Manual, NAVAIR 01-1A-17, Commander, Naval Air Systems Command, Washington, D. C., 1 February 1992.